FOIA Number: 2017-1095-F

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

Collection/Record Group: Clinton Presidential Records

Subgroup/Office of Origin: Council of Economic Advisers

Series/Staff Member: Subject Files

Subseries:

OA/ID Number: 21605

FolderID:

Folder Title:
Climate: Budget, CCTI [Climate Change Technology Initiative], Volume Programs [Binder] [2]

Stack:	Row:	Section:	Shelf:	Position:
S	21	5	1	2

Short Briefing Note with Anecdotal Evidence on Impacts and Ranges of Free Riders, Free Drivers, and Spillovers Effects on ENERGY STAR Buildings[SM] and Green Lights®

Executive Summary

This paper indicates that EPA's Green Lights and ENERGY STAR Buildings programs have interesting (if not unique) structural characteristics that have an intrinsic economic tendency to lower free ridership and increase free drivership rates. EPA is currently involved in a formal evaluation of the Green Lights and ENERGY STAR Buildings programs. The estimated impacts of free riders, free drivers, and spillover effects on overall energy savings and pollution prevention will be provided at the conclusion of that analysis.

In the interim, a review of past utility analysis and anecdotal evidence indicates that the free ridership rate could reasonably fall between 10% and 20% of the participants' kilowatt-hour (kWh) energy savings. Eto's report indicated a 12.2% free ridership rate for the 40 largest commercial utility DSM programs. Thus, 12.2% appears to be a reasonable *a priori* free ridership rate estimate.

Background information on free drivership rates is scarce. However, free drivership rates have been estimated between 2% and 10% of the non-participants. A conservative estimate would be approximately 2%. However, it has been shown that the Green Lights and ENERGY STAR Buildings programs have certain aspects that could encourage free drivership. It is believed that the free drivership rate is likely higher.

If the kilowatt-hour per square foot impact is the same, then every percentage point of a free driver equates to approximately 7% points of free ridership. Thus, a 12.2% free ridership rate would be approximately offset by a 2% free drivership rate.

Therefore, preliminary anecdotal evidence indicates that, in a conservative estimate, the effects of free riders and the effects of free drivers in the Green Lights programs would likely offset each other on a kWh basis.

Spillover effects were the least well known. This paper looks briefly at two EPA related studies. One addressed under-reporting of participants and the other examined the indirect demand effects of EPA's Green Lights® program. The two estimates were 1.4% to 4.7%[1]. If a point estimate is needed, the midpoint estimate is approximately 3%.

---

[1] Both of the percentages were given within the framework of non-participants for consistency purposes.

Introduction

The purpose of this briefing paper is to focus on three relatively complex analytical areas in EPA ENERGY STAR Buildings and Green Lights program energy impact evaluation. The three impact areas are a) free riders, b) free drivers and c) spillover effects. We will define these concepts, briefly discuss them, explain how EPA plans to evaluate its program to account for these effects, and then provide anecdotal evidence for expected range of values for these effects. It should be noted that this information is preliminary in nature. EPA is conducting a full-scale impact evaluation of the Green Lights® program which will develop more precise, statistically based estimates of these effects.

Definitions and Discussions

Free riders are defined to be participants in an energy efficiency program who would have undertaken the same energy efficiency actions if the program were not available. In order to be a free rider, the customer (or program partner) must be able to perform the upgrade action independent of the program. Estimates of free ridership vary considerably from study to study. In general, the rate of free ridership is often positively related to the amount of incentive that the program is offering. Despite considerable research in the area of free rider measurement, there is no definitive formula for accurately determining free rider rates.[2]

The opposite of a free rider is a *free driver*. Free drivers contribute to the desired program impacts without formally joining the program or taking full advantage of what the program is offering.[3] An example of free drivers are individuals who purchase compact fluorescent lamps that have rebates associated with them. When the individuals do not send in the rebate coupons, the individuals become free drivers. They took the desired action (i.e., purchased the compact fluorescent lamp) and realized the associated energy savings, but did not "participate" in the program or avail themselves of the program benefits. Thus, for the Green Lights Program, the free drivers do not join the program but do avail themselves to the EPA provided information and upgrade their lighting systems. There has been less analytical work and studies conducted on free drivers. The comment made for free riders applies (only more so) to free drivership estimation.

Spillover effects exist when an EPA Green Lights® program participant commits to upgrade lighting efficiency, upgrades the lighting system, and then goes on to include other energy efficiency upgrades. Many business owners, limited by tight budgets (and uncertain of the potential benefits of upgrading to energy efficient

---

[2] William P. Saxonis, (1991). Measuring Free Riders: Does the Economic Climate Make A Difference? In Energy Program Evaluation: Uses, Methods, and Results: Proceedings, CONF-910807. Chicago: 1991 International Energy Program Evaluation Conference. P. 284.

[3] The company takes advantage of the publicly available information but is not able to avail itself to the public recognition nor the Green Lights logo.

equipment), tend to start off with relatively simple and inexpensive lighting upgrades. However, once they have seen their energy bills drop, sometimes dramatically, many of them are eager to find other profitable upgrades. This creates spillover effects.

EPA Evaluation Activity

Introduction

EPA is currently undertaking a national full-scale evaluation of its ENERGY STAR Buildings and Green Lights program. The evaluation will focus on the Green Lights® lighting upgrade portion of the program since this is the older program has sufficient historic participation for meaningful measurement. The evaluation plan consists of three major segments: a) participants, b) non-participants, and c) overall net market transformation. While a number of utilities have analyzed their lighting programs, within their service territories, nation-wide program analysis for a national market transforming energy efficiency program has rarely been done. Such an analysis presents difficulties since there are no readily available comparison groups which are completely unaffected by the program (as in the case with utility program evaluations).

It is important to note that EPA's ENERGY STAR Buildings and Green Lights program is voluntary. These programs have significant outreach emphasis. Participation is without apparent cost to the participant, and EPA provides no direct payments. However, EPA program does have reporting requirements. Thus, there is a cost to the company to participate. The cost to the participant is related to the amount of effort needed to fulfill reporting requirements. Thus, EPA's Programs have an intrinsic economic twist. Because there is no direct payment, free riders are discouraged; and for the same reason, the free drivership impact is expected (from an economic standpoint) to be larger than usual. This occurs because some companies will find it cost effective to avoid the reporting cost by not formally joining the program, but will simply use the EPA provided information and tools to upgrade the efficiency of their energy using devices.

Participant Evaluation

The participant evaluation segment will address the confirmation and reporting of participant impacts. This will be a two-part study. The first part of the study will be a telephone survey. The survey will be used to verify that reported energy efficient devices have been installed and are operating under reported parameters and conditions. Time has passed since the companies have signed the memorandum of understanding (MOU) with EPA. Circumstances and situations can change a company's operational characteristics over time.

After this information is collected, the second part of the study will use a subsample of the first. For this subsample, participant buildings will be audited to reaffirm the responses received by the participants and to systematically verify device installation, energy savings (using EPA algorithms), and square footage. The precision of the audit data will be used to adjust the telephone survey results, and these adjusted results, in turn, will be used to revise the initial participants impact estimates. This approach is known as a double ratio or double sample technique.[4] The evaluation literature has accepted this approach and shown it to be cost-effective.

Non-Participant Analysis

The second segment of the evaluation plan addresses that part of the commercial and institutional buildings sector that does not participate in EPA's programs. This segment will identify the proportion of the non-participant population that has not engaged in energy efficient upgrades. These companies will be removed from the sample. The remaining sample will be surveyed. It is anticipated that a telephone-mail-telephone type survey will be used to estimate the proportion of free riders, free drivers, and indirect impacts due to EPA's programs.

The proportion of free ridership will be multiplied times the participant's estimated impact to obtain the kWh impact attributable to free riders.[5] The free rider impact amount is then subtracted from the participant's impact estimate to arrive at the net kWh savings of EPA's program due to participants. Free drivership and indirect impacts are related concepts and, consequently, treated similarly. The proportion of free drivership will be multiplied times the non-participant's estimated impact to obtain the amount of the impact attributable to free drivers.[6] The main difference is that free driver and indirect impacts are calculated using the non-participant population. The free driver and indirect impact amounts will be added to the participant net impact estimate to arrive at the impact of EPA's program, measured in kWh savings and associated pollution prevention.

Market Transformation

The final segment will formally model the degree of market transformation in the energy lighting marketplace due to EPA programs. Econometric and cross-section analysis will be used (when appropriate) to estimate the impacts

---

[4] Roger Wright. (1993) Model-Based Sampling For End-Use Metering. CEED session paper, Portland: Electric Power Research Institute. Pp. 9-12.

[5] Note: the impact is calculated in terms of kWh savings, and associated pollution prevention. Gross kWh program impacts are adjusted by the kWh impact of free riders (downward adjustment) and the kWh impacts of free drivers and spillover effects (upward adjustment) to result in program "net" impact, as measured in kWh savings and associated pollution prevention.

[6] Note: the impact is calculated in terms of kWh savings, and associated pollution prevention. Gross kWh program impacts are adjusted by the kWh impact of free riders (downward adjustment) and the kWh impacts of free drivers and spillover effects (upward adjustment) to result in program "net" impact, as measured in kWh savings and associated pollution prevention.

attributable to EPA, utilities, and cross EPA/utility effects. The net of the free drivers minus free riders (calculated above) will be subtracted from the estimate attributable to EPA (to avoid double counting). The remainder will be added to the estimated EPA program impact to obtain the total EPA program impact including market transformation effect. (This is an extra step beyond traditional utility DSM impact evaluation, in an attempt to calculate overall national market transformation effect.)

Thus, there is work in progress to examine and analyze EPA program energy impacts. Until that work is finished, we will not have definitive answers to evaluation-based questions (e.g. free ridership rate). In the interim, to frame the issues and provide some background information, we will provide examples of previous results from different programs and anecdotal evidence of the existence and relative magnitude of some of the problem areas.

Documentation and Anecdotal Evidence

Free Riders

Free riders are defined to be participants of an energy efficiency program who would have undertaken the same energy efficiency actions if the program were not available. There is no definitive approach for accurately determining free rider rates.[7] Estimates vary. For Commercial/Industrial energy efficient lighting programs, Nadel found that the free ridership rate varied from 6 to 23% for the New England Electric System.[8] For the Niagra Mohawk Power Company Commercial/Industrial Lighting Program, the free readership rate for 1990 and 1991 was approximately 13%; the 1992 free ridership rate was 23%.[9] The Pacific/Utah Power views its Commercial energy efficiency program Energy FinAnswer to have a free ridership rate from 5% to 10% of its participants.[10] A study conducted by Lawrence Berkeley National Laboratory (examining 40 of the largest commercial sector DSM programs) found that the average free ridership rate was 12.2 %.[11] It seems reasonable to assume that, for a program that provides no cash payments, the free ridership rate could fall between 10% and

---

[7] William P. Saxonis, (1991). Measuring Free Riders: Does the Economic Climate Make A Difference? In Energy Program Evaluation: Uses, Methods, and Results: Proceedings, CONF-910807. Chicago: 1991 International Energy Program Evaluation Conference. P. 284.
[8] Nadel, Steven. (1988). Utility Commercial/Industrial Lighting Incentive Program: A comparative Evaluation of Three Different Approaches Used by the New England Electric System. Proceedings of the 1988 ACEEE Summer Study.
[9] The Results Center. (1993). Niagra Mohawk Power Corp Commercial/Industrial Lighting. Profile #69. P. 11
[10] The Results Center. (1993). Pacific Corp Large Commercial Energy FinAnswer. Profile #46. P. 14
[11] J. Eto, S. Kito, L. Shown, and R. Sonnenblick (1995). Where Did the Money Go? The Cost and Performance of the Largest Commercial Sector DSM Programs. LBL-38201 UC1322 Prepared for the U.S. DOE DE-AC03-76SF00098. Berkeley: Lawrence Berkeley Laboratory p. 40

20%. If a point estimate is needed, Eto's 12.2% average commercial sector DSM estimate appears to have the most support.

Free Drivers

Free drivers contribute to the program activities without formally joining the program. In this case, building owners that are influenced by EPA's outreach and market transforming activities would engage in energy saving activities without signing a Memorandum of Understanding (MOU). Because their behavior results directly from program activity (and the information and tools provided therein), they are; in essence, partial-participants in the program, and their savings are attributable. Information on free drivers is even less available (or consistent) than that on free riders. Free driver savings are positive but their magnitude is generally unknown.[12] The omission of free driver impact is a known source of analytical bias.

Northern States Power Company's analysis of one of its programs showed that only about 40% of its customers who took a desired energy efficiency action applied for the associated qualifying rebate. This implies a 60% free driver rate.[13] At the other extreme, a free driver rate of 1% was estimated for Orange and Rockland Utilities Inc.'s Clock Thermostat Rebate Program.[14]

Free drivers are of particular interest to EPA's programs. EPA's ENERGY STAR Buildings and Green Lights program is voluntary, and EPA provides no direct payments. However, EPA's program does have reporting requirements. Thus, there is a cost to the company to participate. If the reporting costs are deemed to be greater than the benefits of being a participant, then a building owner may elect to not sign an MOU but to engage in the energy savings activities anyway. The potential of free drivers is significant for the EPA's ENERGY STAR Buildings and Green Lights program.

EPA activities are out-reach oriented and could encourage free drivership (indeed, as a market transformation program, are in a sense designed to do so). EPA's ENERGY STAR Buildings and Green Lights program has a web-site

---

[12] Richard Sonnenblick and Joseph Eto. (1995). Calculating the Uncertainty in Estimates of DSM program Cost-Effectiveness. In Energy Program Evaluation: Uses, Methods, and Results: Proceedings, CONF-950817. Chicago: 1995 International Energy Program Evaluation Conference p. 765

[13] William Saxonis, (1991). Free Riders and Other Factors That Affect Net Program Impacts. Hirst, E and Reed, J. editors. In Handbook of Evaluation of Utility DSM Programs. ORNL/CON/-336. Oak Ridge, TN: Oak Ridge National Laboratory. P. 132

[14] Eric Meerdink and Leslie Carlson. (1995). Behavior and Technology: The Evaluation of a Gas Heat Clock Thermostat Program. In Energy Program Evaluation: Uses, Methods, and Results: Proceedings, CONF-950817. Chicago: 1995 International Energy Program Evaluation Conference. pp. 507

homepage and a telephone hot line. Moreover, EPA uses the media. In FY1997, EPA placed 40 public service ads that reached an estimated 15 million people and had an estimated dollar value of $573,000. In FY1998, EPA placed 93 public service ads with an estimated circulation of 18 million and an estimated value of $957,000. This advertising has broad market appeal.

As a result, there is a large interest in EPA's Programs. In the month of October 1998, the ENERGY STAR Buildings and Green Lights homepage received 3,742 hits. For the same month the hot line had 385 calls. Of the 385 calls, 14 were from ENERGY STAR Buildings participants. Thus, 371 were non-participants. A portion of these non-participants could become free drivers based on the information given them by the hot line operator. It is estimated that between 90 to 95% of all the hot line calls are from ENERGY STAR Buildings non-participants.[15] This represents a significant pool of potential free drivers.

EPA also has EPA ENERGY STAR Buildings Program workshops - "Building Momentum." Of the 15 Building Momentum workshops only 55 (12%) of the 446 attendees were ENERGY STAR Buildings Partners or Allies. Other attendees included Green Lights Allies, Green Lights Partners, ENERGY STAR Buildings prospects and others (i.e., non-participants in any EPA partnership).

Of these, 102 workshop non-participant attendees (i.e., those who did not participate in an EPA sponsored program) were contacted during the six-month follow-up evaluations. Eighteen (17.6%) exhibited characteristics of free drivers. That is, these workshop attendees were not ENERGY STAR Buildings participants but they have upgraded the efficiency of their lighting equipment. The attendees have taken the actions advocated in the workshops but have not signed an MOU. As such, these companies can be designated free drivers. It is preliminary estimated that the national free drivership rate is between 2% and 10%.

Target Populations

It is important to understand that the population for free drivers is not the same as the population for free riders. Free riders are estimated from the participant population. The free ridership kWh impact rate is calculated by multiplying the free rider rate times the participant's kWh energy savings impact. Free drivers are estimated from the non-participant population. The free drivership kWh impact rate is calculated by multiplying the free driver rate times the non-participant's kWh impact. For utilities this difference may not be a large issue because all of their customers are confined within the utility's service territory. For the EPA programs, however, the difference between the magnitude of the two groups is significant.

The EPA program participants represent 8.2 billion square feet of the commercial sector. The commercial sector has a total of approximately 58 billion

---

[15] Based on telephone call to Hot-line Program Manger Dec. 20, 1998.

square feet.[16] EPA programs represent approximately 14% of all of the commercial square footage. A 10% free ridership rate affects 820 million square feet. A 10% free drivership rate affects 5.8 billion square feet. If the kilowatt-hour per square foot impact is the same, then every percentage point of a free driver equates to approximately 7% points of free ridership. Thus, a 20% free ridership rate would be offset by a 3% free drivership rate.

Spillovers

Spillover effects are complex to analyze. Spillovers are market indications of a change in the perception energy efficiency cost-effectiveness by the business owner. Spillover effects are affected by a large number of factors - some of which are: technological characteristics and options, price of energy, site location, climatic variations, the presence of accurate information, word-of-mouth, previous experience, and individual preference functions.

For example, one of the major barriers to cost-effective pollution prevention (e.g., energy-efficient lighting improvements) is that people don't know about the benefits of taking action. Through broad education campaigns and word-of-mouth from EPA's 2,300 partners, Green Lights has dramatically improved awareness well beyond those companies that directly participate in the program. These impacts are not claimed by the programs in reporting results. For example, Woolworth is pursuing lighting upgrades because an employee of another Green Lights partner –Service Merchandise Inc. --moved to Woolworth and persuaded them that it was a good idea. Although they are doing the upgrades and preventing pollution, Woolworth did not sign a commitment with EPA. Thus, Woolworth impact has not been included in EPA's estimate. Although, it was EPA provided information that was used to upgrade Woolworth lights.

Anecdotes

EPA has collected a large number of these testimonials. Presented here are public statements made by the representatives of Johnson and Johnson, Mobil, St. Mary's Hospital, and Carrier. Mobil's interest has spilled-over internationally.

"(Mobil's) Energy Managers Network invites our partners around the world to participate in our internal activities. We've conducted seminars overseas in a number of countries; and again we are proud and happy to talk to anyone that would listen."[17]

There is strong evidence for the existence of spillover effects. EPA's ENERGY STAR and Green Lights® program participant's have provided testimonials

---

[16] This estimate was taken for the 1995 CBECs database.
[17] Bob Swanson, Mobile Corporation. EPA ESB Awards Video. 1998

indicating the existence of spillover effects. Four examples of statements made by EPA's ENERGY STAR and Green Lights® program participants are given below:

1. *"With the money we are saving under the Green Lights® program we have expanded into other energy savings products.[18]"*
2. *"Other MCI facilities are beginning to take notice of my (Green Lights®) work, and have begun to implement their own energy conservation programs as well.[19]"*
3. *"The process of getting management to fund energy conservation projects had been made much easier since our participation in the Green Lights® Program.[20]"*
4. *"It's been a challenge; it's been fun, and being bounded only by my imagination. There've been all kinds of things we have yet to create and make work.[21]"*

ENERGY STAR Small Business has also produced a number of case studies about owners that have profitably upgraded to energy efficient equipment. Following is a summary of a business that started off with lighting upgrades, but quickly realized that they could save even more energy and money another example of spillover.

Example. Michael Nobles, owner of Manco Management Company in Mary Esther, Florida, manages seven Subway franchises with another one under construction. He had a local supplier of high-efficiency lighting give him a presentation, but he wasn't really sold on the value of energy efficient lighting until he received a free energy audit from the University of West Florida.

The first recommendation of the audit was to replace the inefficient lighting in his stores with new, highly efficient T-8s. He replaced the 4-bulb, 47-watt fixtures in two of his stores with 2-bulb, T-8 fixtures with electronic ballasts. All told, he replaced 152 47-watt lights with 76 T-8s. He spent $1,178, but he's saving a total of $2,400 for both stores.

He was so impressed with his savings that he quickly turned his attention to the other recommendations the audit made. He put timers on his tea and coffee urns at these two stores. Total cost was $48 dollars, but he's saving about $110 annually for both stores. He then installed timers on the hot water heaters at both stores for a total cost of $28. That alone cut his energy costs an estimated $492.

[18] Mile Vlasic, McNeil Consumer Products Company (Johnson and Johnson), Fort Washington, PA. Energy Star Information Card.
[19] Mike Popovic, Facility Manager, MCI/Downer's Grove. Energy Star Information Card.
[20] Greg Lowe. Manager, Facilities and Maintenance Service. United Technologies Carrier. Energy Star Information Card
[21] Ken F. Elkern, Director – Facilities Management Services, St. Mary's Hospital. EPA ESB Awards Video 1998.

Nobles used two of his stores as test cases, but now plans to upgrade his lights and install timers at his other stores, as well.

Energy savings from lighting upgrades----$2,400
Energy savings from other upgrades-------$602
Total energy savings------------------------$3,002 per year

Spillover effects are complex to analyze. However, it is anticipated that the spillover effects will be comprised of 1) the additional activities of participants and 2) market transformation affects. Spillover effects will be positive but the magnitude of the national effect is not known at this time. The extra-program activities of the participants (under-reporting) will be estimated from the first segment of the EPA evaluation plan. Market transformation is the focus of the third segment.

A recent study indicates that Green Lights partners fail to report approximately one-third of their total lighting upgrades.[22] Duke and Kammen indicate that the Green Lights program reduced the national price of ballasts by 1.4%[23]. This implies that the EPA program is having national price impact effects. Reducing the participant spillover estimate to be consistent with the national price impact on ballasts (i.e., non-participants) the spillover estimate ranges from 1.4% to 4.7%. These are very rough estimates. One purpose of the EPA evaluation plan is to obtain accurate estimates of spillover impacts.

Conclusion

We have seen that the EPA programs have interesting (if not unique) structural characteristics that have an intrinsic economic tendency to lower free ridership and increase free drivership rates. EPA is currently involved in a formal evaluation of their programs. The estimated impacts of free riders, free drivers, and spillover effects on overall energy savings and pollution prevention will be provided at the conclusion of that analysis.

However, in the interim, anecdotal evidence indicates that, in a conservative estimate, the free drivership rate would likely offset the free drivership rate effect on a kWh basis.

This anecdotal evidence indicates that the free ridership rate could reasonably fall between 10% and 20% of the participants kWh energy savings. The Eto report indicated a 12.2% free ridership rate from the 40 largest commercial utility DSM programs. It is believed that if a point estimate is needed, then the Eto number should be used.

---

[22] Richard Duke and Daniel Kammen. Evaluating Market Transformation Programs: Integrating Experience Curves and Demand Theory. In Review: Energy Journal. P. 17.
[23] This estimate includes indirect demand effects.

There was less background information on free drivers. Free drivership rates were estimated between 2% and 10% of the non-participants. It has been shown that the EPA Program has certain aspects that could encourage free drivership. The most conservative estimate would be 2%. It is believed that the free drivership rate is likely higher. A 2% free drivership rate would likely offset most, if not all, of the free ridership effect on a kWh saving basis.

If the kWh per square foot impact is the same, then every percentage point of a free driver equates to approximately 7% points of free ridership. Thus, a 12.2% free ridership rate would be approximately offset by a 2% free drivership rate.

Spillover effects were the least well known. This note looked briefly at two EPA related studies. One addressed under-reporting of participants and the other examined the indirect demand effects of EPA's Green Lights® program. The two estimates were 1.4% to 4.7%[24]. If a point estimate is needed, the midpoint estimate is approximately 3%.

As indicated throughout this document, care needs to be taken when dealing with free ridership, free drivership, and spillover effects. While the theory on these topics is well developed, conclusive methodologies, estimating procedures, and robust estimates are still needed. Moreover, EPA's national programs represent a different client base than those given by the utilities. The non-participant population is approximately seven times larger than the participants are. Consequently, free ridership and free drivership rate impacts are <u>not</u> comparable on one-to-one percentage basis.

[24] Both of the percentages were given within the framework of non-participants for consistency purposes.

Final

Green Lights and Energy Star Buildings Program Energy Evaluation Scoping Study: Phase I

Submitted to:

Atmospheric Pollution Prevention Division
U.S. Environmental Protection Agency

Submitted by:
Aspen Systems Corporation
EPA Contract No. 68-W6-0032
Work Assignment 0003AA-08

October 28, 1998

Aspen Systems Corporation
An Employee-Owned Company

Task 2: Evaluation Scoping Study, Phase I

Table of Contents

		Page
1.	Program Background Information	1
2.	Introduction and Summary	3
3.	Overarching Issues	7
	3a. Sample Sizes	7
	3b. Baselines	7
4.	Energy-Savings' Impact Measurement and Adjustments	9
	4a. Engineering Energy Impact Estimations	9
	4b. Engineering Method Strengths and Weaknesses	9
	4c. Examination and Adjustment of Participants Energy Impacts	10
5.	Self-Selection Bias	11
6.	EPA Program-Related Impacts on Partial- and Non-Participants	13
7.	Market Transformation	16
	7a. Changes in Market Frequency Distribution	16
	7b. New Technology Market Penetration	19
8.	Calculating the Green Lights and Energy Star Building's Impact Estimate	22
9.	Data Requirements, Sampling Needs and OMB Clearance	22
10.	Summary	23
11.	References	25
12.	Appendix A. EPA ENERGY STAR Building's Agreement Information	27

List of Figures

	Page
Figure 1: Estimated Annual Energy Savings	1
Figure 2: Total Square Footage Recruited	2
Figure 3: Schematic Diagram of the Evaluation process	6
Figure 4: The Process of Energy Evaluation	8
Figure 5: Systematic Overstatement of Savings	10
Figure 6: Systematic Bias	12
Figure 7: Partial-Participants	14
Figure 8: Mean-Changing Market Transformation	17
Figure 9: Variance-Changing Market Transformation	17
Figure 10: Variance-Changing Market Transformation	18
Figure 11: Mean- and Variance-Changing Market Transformation	18
Figure 12: Adoption Patterns in a Diffusion Model	21

Contract No. 68-W6-0032
Work Assignment 0003AA-08
ENERGY STAR Buildings℠ and Green Lights®
Program Energy Evaluation

Task 2: Evaluation Scoping Study, Phase I

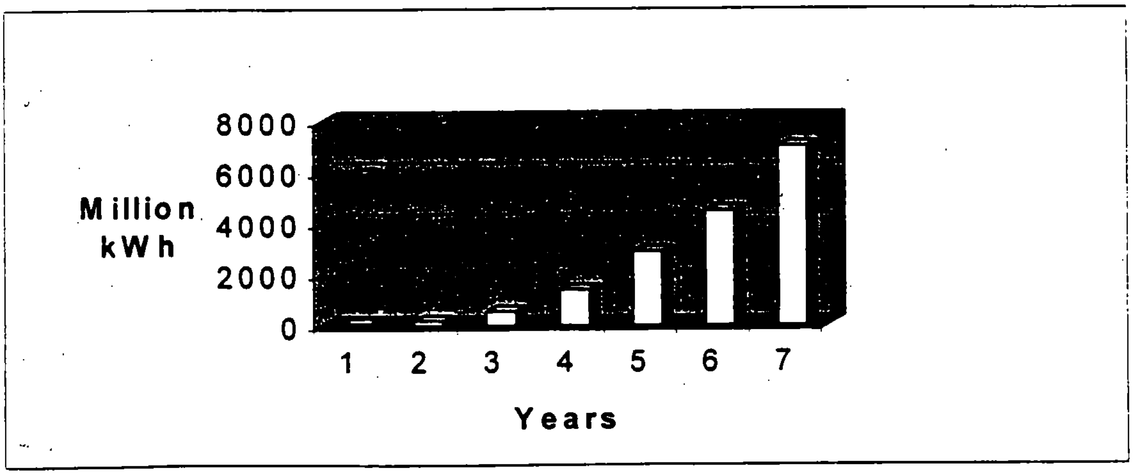
1. ENERGY STAR Buildings and Green Lights Program Background Information

EPA initiated the Green Lights Program in 1991. Its goal was to create a voluntary money-saving energy-efficiency program that would have positive environmental impacts. The Green Lights Program set out to prove that the public and private sectors could work together in a meaningful partnership.[1] The program has been viewed as a success.

Green Lights participants fall into three categories: Partners, Allies, and Endorsers. Partners are public or private organizations that upgrade their lighting whenever profitable. Allies are companies in the lighting or energy industry that perform upgrades in their own facilities and promote energy-efficiency technologies to customers. Endorsers are professional and trade organizations that promote the program to their membership.[2]

Since 1991, the ENERGY STAR Buildings and Green Lights Program participation has grown to more than 2,600 organizations. These organizations experienced estimated annual energy savings of more than 7 billion kWh. Figure 1 shows the estimated annual energy savings from 1991 to 1997 from the ENERGY STAR Buildings and Green Lights Program.

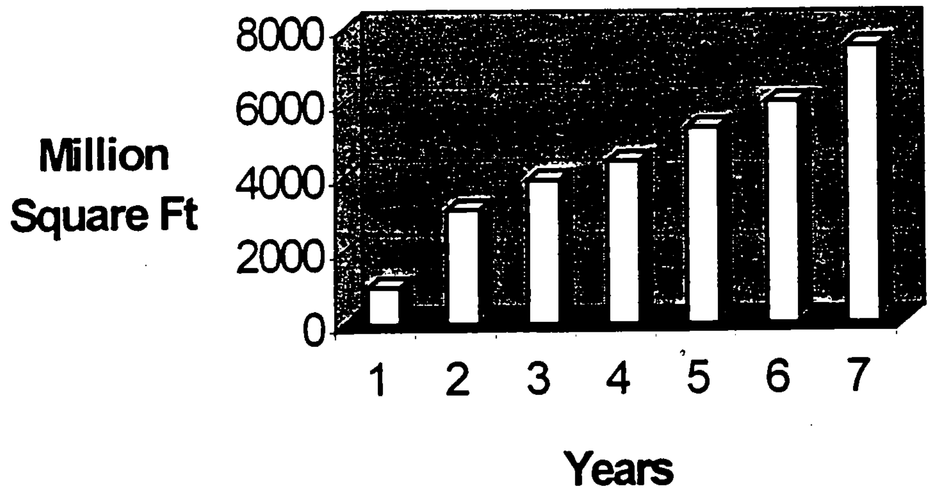
Figure 1: Estimated Annual Energy Savings



[1] Environmental Protection Agency (May 1997). *Building On Our Success: Green Lights and Energy Star Buildings 1996 Year in Review.* EPA 430-R-97-002. Washington, DC: EPA, p. 2.

Since 1991, the ENERGY STAR Buildings and Green Lights Program participation has grown. In 1997, 7.5 billion square feet, representing 10% of the entire commercial and industrial facility space in the U.S, was included in the program. The total square footage recruited for the years 1991 to 1997 is shown in Figure 2.

Figure 2: Total Square Footage Recruited



To date, ENERGY STAR Buildings and Green Lights participants have voluntarily worked to incorporate energy-efficient technologies into current business practices. As a result of their efforts, participants have accomplished the following:

- Improved building lighting for 40 % less energy;
- Completed energy-efficient lighting and whole-building upgrades in 2.8 billion square feet of facility space;
- Prevented more than 11 billion pounds of greenhouse gas emission per year;
- Estimated reduced electricity consumption by more than 7 billion kilowatt-hours per year; and
- Saved more that $514 million per year in energy costs.[3]

---

[2] Environmental Protection Agency (May 1997). *Building On Our Success: Green Lights and Energy Star Buildings 1996 Year in Review.* EPA 430-R-97-002. Washington, DC: EPA, p. 5.
[3] Environmental Protection Agency (April 1998). *Helping Build a Better Future: Energy Star Buildings and Green Lights 1997 Year in Review.* EPA 430-R-98-001. Washington, DC: EPA, p. 1.

2. Phase I Scoping Study: Introduction and Summary

The purpose of the Aspen scoping study is to systematically develop an accurate, statistically defensible evaluation methodology for the Green Lights and ENERGY STAR Buildings program energy evaluation.[4] This is a Phase I evaluation scoping study. The purpose of a Phase I scoping study is to lay the preliminary theoretical and statistical ground work for the more detailed Phase II study. In Phase I Aspen will do the following:

1) Present the formal approach for impact measurement of the 2308 Green Lights participants and adjustments,

2) Develop a statistically acceptable, systematic approach for the elimination of self-selection bias,[5] (note, free ridership is one element of the larger problem of self-selection bias.),

3) Discuss a methodology that allows for the estimation of attributable, positive, and EPA program-related impacts on non-participants[6],

4) Discuss market transformation issues, impacts, and analysis,

5) Indicate what is required to calculate the total EPA program-related impacts, and

6) Discuss data requirements, sampling needs and OMB clearance.

This scoping paper develops an evaluation methodology that encompasses five activities.

First, Aspen will evaluate the existing Green Lights and Energy Star Buildings Program's technical energy savings estimates.[7] The estimates are compared with the energy savings of a random[8] sample of program participants to determine the validity of the estimates. If the program participants' mean and the sample mean fall within the

[4] Aspen will work with EPA staff to determine the level of accuracy necessary to make the evaluation, statistical, and analytical methods useful for EPA reporting purposes.
[5] RCG/Hagler Bailly, Inc. (February 1991). Impact Evaluation of Demand-Side Management Programs: Volume 1: A Guide to Current Practice. EPRI CU-7179, volume 1, project 2548-11. Pp. 2-31
[6] This program impact is also known as "free drivers".
[7] Technical energy savings estimates are those estimates that are based solely on engineering estimates of energy use.
[8] Random, as it is used here, implies equal probability of being selected.

accepted[9] confidence interval, then the technical energy saving estimates are validated and Aspen will proceed to correct for self-selection bias. If the two energy-savings means are statistically different, then Aspen will adjust the program energy-savings estimates accordingly through the ratio technique.

The ratio technique uses the sample to estimate the relative difference between the technically estimated and the realized energy savings.[10] The estimated relative ratio between the sample mean and the estimated technical mean is used to adjust the population's estimated mean energy savings. This procedure increases precision by taking advantage of the correlation between the technically estimated and realized energy savings[11].

Second, given the voluntary nature of the Green Lights and ENERGY STAR Buildings participants, Aspen will conduct tests for self-selection. If detected, self-selection bias will be removed from the energy-savings estimate. The most common example of self-selection bias is free riders. A *free rider* is an entity who would have taken a program action even if the program did not exist. Thus, this action would have occurred in the absence of the program. The impact is not a result of the program. Therefore, the affects of the entity's actions should not be counted among the affects of the program. Consequently, it is necessary to separate the self-selection biased data from the program impacts. Data on self-selection bias is often difficult to collect.[12]

Another example of self-selection bias could be a participant's natural tendency to use less energy. Thus, when Aspen corrects for self-selection biases, the estimates will be corrected not only for free ridership, but for other biases as well. Once program's impact estimates have been adjusted for realized vs. technical energy-savings estimates and the self-selection bias has been removed, Aspen will calculate the unbiased Green Lights and ENERGY STAR Buildings program's participants' actual energy savings.

Third, Aspen will research and include partial-participant energy-savings data among savings attributable to the Green Lights and ENERGY STAR Buildings Program. Partial-participants, also known as free drivers, represent the positive counterpoint to free riders. They contribute to the program activities without formally joining the program. Influenced by EPA's outreach and market transforming activities, free drivers engage in energy saving activities without signing a Memorandum of Understanding (MOU) and without receiving full benefits of program partnership. Yet their behavior results directly from program activity and thus, they are, in essence, partial-participants in the program, and their savings are attributable.

---

[9] EPA will be asked for input on the acceptable level of confidence, and standard errors.

[10] Technical energy savings estimates are those estimates that are based solely on engineering estimates of energy use. Whereas, realized energy savings are those shown to have actually occurred.

[11] William G. Cochran. (1977). *Sampling Techniques*. Third Edition. Santa Barbara: John Wiley & Sons. pp. 150-151

[12] Programs that offer rebates or some form of payment produce a paper trail, which can be used later for reference. Because no money changes hands between EPA participants in the Green Lights and Energy Star Buildings Program data collection and estimation procedure might be more difficult.

The ENERGY STAR and Green lights program is voluntary. This program supports significant outreach emphasis. Participation is without cost to the participant, and EPA provides no direct payments. However, there are reporting requirements and a formal agreement signing. See Appendix A for a copy of the ENERGY STAR Buildings Annual Filing Report , the common agreements and principles of the ENERGY STAR Buildings MOU in Brief and a copy of the MOU. Some companies are reluctant to sign a formal agreement to participate. Thus, a situation could develop where companies are positively influenced by EPA program's activities, perform program actions, without signing an MOU, don't acquire nor receive the full benefits offered through full program participation.

Sound statistical practice requires symmetric analytical behavior when addressing positive or negative biases. Consequently, the partial-participants' increase in energy impacts need to be included in the energy impact estimates attributed to the Green Lights and ENERGY STAR Buildings Program's activities.

Fourth, Aspen will estimate and attribute impact market transformation. Market transformation represents a fundamental and permanent shift in consumer behavior resulting from a program. The issue of market transformation is recognized as an important program impact. It is EPA's primary goal to achieve market transformation. This can occur with or without an individual company being a member of the ENERGY STAR Buildings and Green Lights Program. Market transformation impacts can be difficult to measure and attribute, however, because they are not isolated to program participation.

The market transformation analysis contains two major components. First, Aspen must estimate the degree or amount of energy-efficiency market transformation that has occurred in the market. And second, Aspen will determine the apportionment of the market transformation to EPA and other market-based energy efficiency programs.

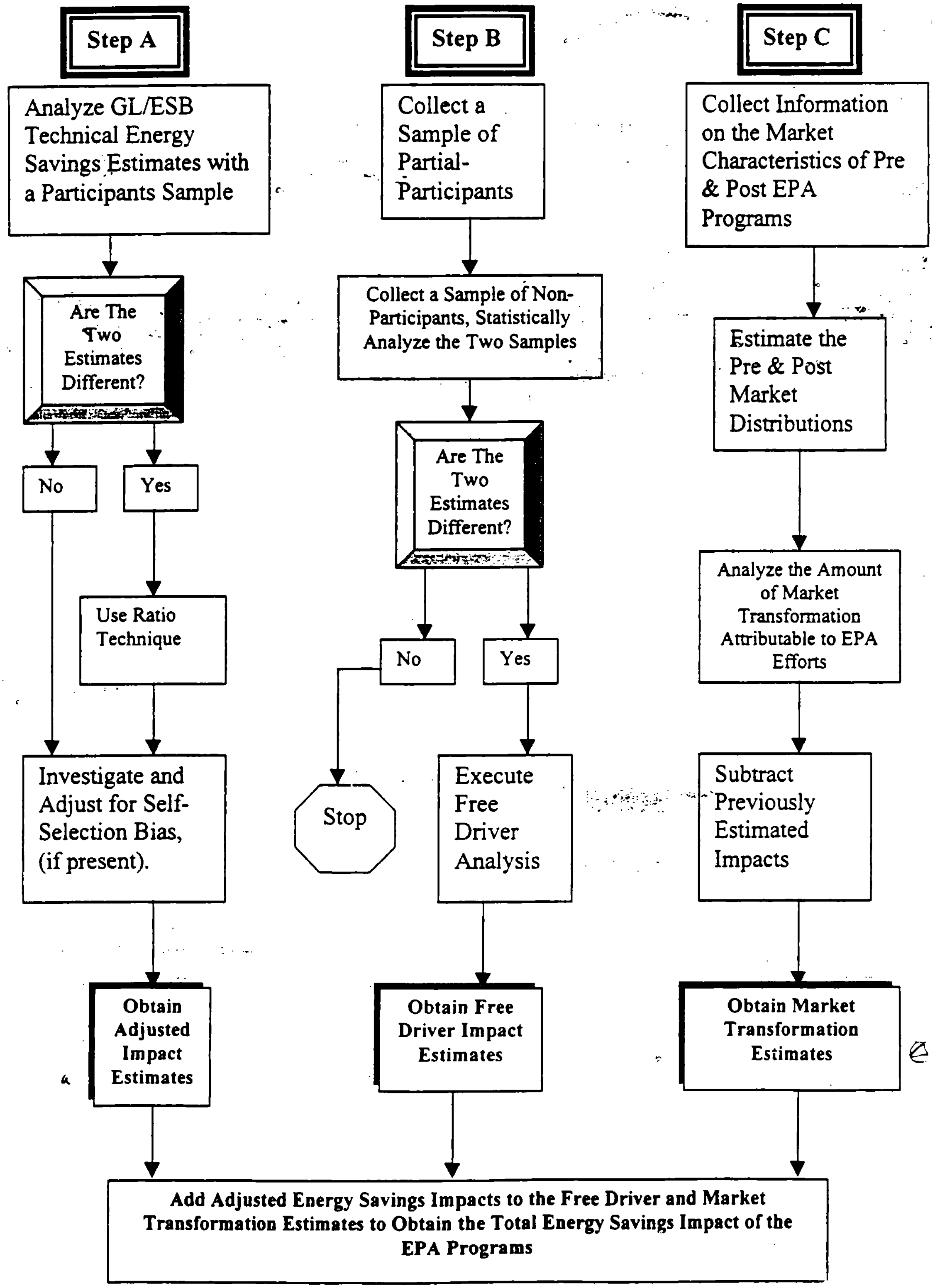
Finally, after all of the estimates have been calculated and reviewed for reasonableness, Aspen will combine all of the unbiased energy-savings estimates. The resulting total will represent a Green Lights and ENERGY STAR Buildings energy-saving impact estimate. The energy-savings estimates will be based on an accurate,[13] consistent, statistically defensible evaluation methodology.

Given the necessity of obtaining information from non-participants and partial-participants, OMB clearance for collection of some of the data will be necessary.

The Aspen evaluation process is portrayed schema[illegible]

[13] Aspen will work with EPA staff to determine the level of accuracy necessary to make the evaluation, statistical, and analytical methods useful for EPA reporting purposes.

Figure 3: Schematic Diagram of the Evaluation Process



3. Overarching Issues

Certain issues transcend statistical technique or approaches. They are important in and of themselves for sound statistical analysis. One important consideration is sample design. In essence, the backbone of statistical inference is the validity of the sampling technique. Statistical inference relies on a chain of links, starting with the original list of participants (sample frame). It is important that the integrity of the chain be preserved. Otherwise, the ability to make statistical inferences suffers. The chain can be portrayed in a line diagram:[14]

Frame → Selection → Probability Sampling → Measurability → Statistical Inference

3a. Sample Sizes

This effort is focused on obtaining an accurate estimate of the total energy-savings impact of the Green Lights and ENERGY STAR Buildings Program. Direct and indirect savings have occurred. Direct savings result from program participants. Indirect savings result from individuals who have been influenced by Green Lights and ENERGY STAR Buildings Program outreach efforts, but are not formal participants. Thus, samples will need to be collected from program participants and non-participants.

There are a number of ways to determine the desired sample size. Aspen will discuss two: the sample mean approach and the proportion approach. If the variance of the total number of participants can be estimated and an acceptable standard error chosen, then the sample mean approach can be used. A randomly selected minimum sample size (n) can be calculated by examining the relationship among the variance, standard error, and maximum error allowable for the analysis.[15] Mathematically, this is expressed as the following:

Sample size (n) = $(Z/r)^2\ (CV)^2$

Where:

CV	=	coefficient of variation
Z	=	the normal deviate associated with the confidence level
r	=	the relative error allowed

3c. Baselines

An energy-use baseline is the amount of demand and energy that either occurs or would have occurred without an energy-efficiency program. Calculating a baseline is the usual start of an impact analysis. Establishing an accurate baseline is very important.[16] Without baseline information, evaluating an energy-efficiency program is more complex and the analyst must rely on a number of assumptions to properly evaluate the impact of

[14] Leslie Kish. (1965). *Survey Sampling.* New York: John Wiley and Sons. P. 27

[15] William G. Cochran. (1977). *Sampling Techniques.* Third Edition. Santa Barbara: John Wiley & Sons. P. 77

[16] Some analysts argue it is the most important part of your evaluation.

the energy-efficiency program.[17] The essence of evaluation is the description of the program's impact as the energy use deviates from the baseline behavior.

Figure 4. The Process of Energy-Efficiency Evaluation

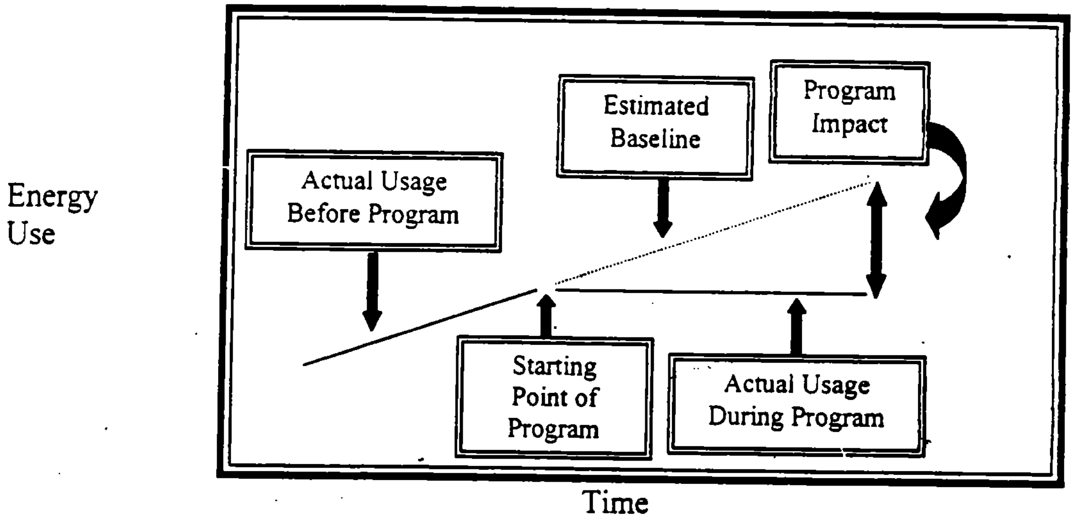


Figure 4 shows the value of calculating an accurate baseline. The diagram illustrates a pre-program growing trend, a program starting point, and subsequent electricity consumption. Let the level of electricity use at the starting point of the program equal 100 gigawatt hours. After an energy efficiency program implementation, the electricity usage patterns level off and end at the same 100 gigawatt hours. Without a proper baseline for comparison, the casual observer might conclude that implementing the program has had little or no impact.

There are three common methods of establishing a baseline:

1) Direct measurement
2) Engineering or technical approach and
3) Statistical approach

Direct measurement measures the difference between actual energy use before and actual energy use after program implementation. Customer and metered data (or both) are the primary measurement tools. The engineering or technical approach uses engineering models to estimate the energy usage employing data such as facility and equipment inventories and energy consumption factory specifications or [illegible] amounts. The statistical approach estimate savings using information on billing, demographic and economic variables and statistics[18] to develop the baseline.

---

[17] Western Area Power Administration and Southwestern Power Administration. (December 1994). *DSM Evaluation Guidebook Part 1: Developing a DSM Baseline.* NREL/SP-462-5859 DE94011806, Golden: National Renewable Energy Laboratory. P. vii.

[18] Western Area Power Administration and Southwestern Power Administration. (December 1994). DSM Evaluation Guidebook Part 1: Developing a DSM Baseline. NREL/SP-462-5859 DE94011806, Golden: National Renewable Energy Laboratory. P. 1-4.

4. Energy Savings' Impact Measurement and Adjustments

At its most basic level, program energy impact evaluation takes data from a pre-installation situation (baseline) and compares it with post-installation information for a post-installation time period.[19]

In general:

Program Energy Impact = Estimated Baseline Energy Use – Post Installation Energy Use

This approach works with existing buildings or retrofit type situations where the number of participants is manageable and cooperative and data are readily available. Typically, billing data is used. Engineering estimates, however, have also been used to estimate program energy impacts in situations in which data availability is an issue. EPA uses engineering-type energy impact estimation for tracking the Green Lights Program. Therefore, we will briefly review the characteristics of engineering-type impact estimations.

4a. Engineering Energy Impact Estimations

Engineering-type or technical energy-savings impact estimations are straightforward. The estimate of the energy use of an energy efficient device[20] is subtracted from the estimate of the energy use of the replaced device (e.g., lights). The results are then scaled up to reflect the number of devices and participants. The calculation of engineering estimates is stated mathematically as:

$$\textbf{Program Impacts} = \Sigma_p \Sigma_m I_m * U_{p,m}$$

Where:

I_m = unit impacts of measure *m*; and

$U_{p,m}$ = number of units of measure *m* for participant *p*.[21]

4b. Engineering Method Strengths and Weaknesses

The engineering method (EM) has a number of strengths and weaknesses. Institutions frequently employ EM because it is inexpensive; easy to employ, and well suited for calculating individual savings within a program. Unfortunately, it also is accurate only to the extent that the assumptions used in the calculations are accurate; not well suited to account for customer choice, attitude, and behavior patterns, and tends to overstate savings. Figure 5 illustrates EM systematic overstatement of savings.

---

[19] United States Department of Energy (December 1997). *IPMVP International Performance Measurement and Verification Protocol:* Expanded Version of 1996 North American Energy Measurement and Verification Protocol. DOE/EE-0157. Washington, D.C. p. 25.

[20] Usually, this estimate is based on manufacturer's data.

[21] RCG/Hagler Bailly, Inc. (February 1991). Impact Evaluation of Demand Side Management Programs: Volume 1: A Guide to Current Practice. EPRI CU-7179, volume 1, project 2548-11. Pp. 4-5.

Figure 5. Systematic Overstatement of Savings

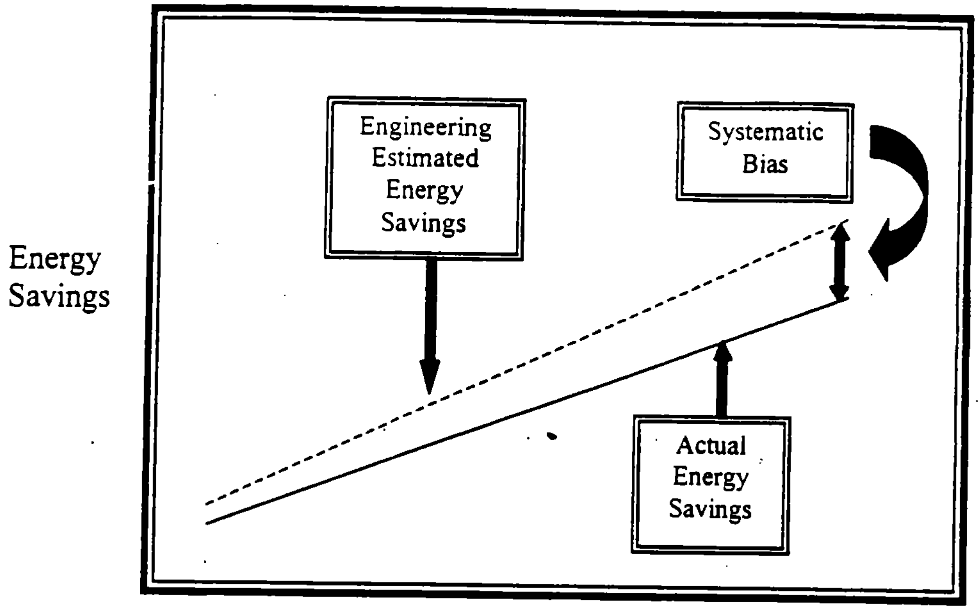


Figure 5 shows the importance of using conservative estimates in an EM type analysis.

4c. Examination and Adjustment of Green Light Participants Energy Impacts

EM tends to overestimate savings because EM estimates are technical potentials. Technical potentials are difficult to attain in the real world.[22] Although EPA's engineering estimates are deliberately conservative, it is prudent to examine the estimates for any systematic bias.

The existence of an upward bias can be determined. Aspen will look and see if it exists. Though a procedure that checks for a difference in means. If a significant difference exists, the upward bias can be removed by the following 12-step approach.

<u>12-Ten Step Approach to Energy Impact Adjustment</u>

1. Assemble the proper database
2. Calculate the technical energy savings (TES) of all Green Lights participants (N).
3. Calculate the participants' technical mean-energy savings (μe) and variance (σ^2)
4. Select a random or equal probability of being selected sample of participants (n_p), using sample size $(\mathbf{n_p}) = (\mathbf{Z/r})^2 \ (\mathbf{CV})^2$[23]

[22] Technical potentials are realized on some occasions. Therefore, it is necessary to check and see if there is a statistical difference in the mean values between EM and Pre and Post data.
[23] Where Z is the normal deviate associated with the confidence level.

5. Calculate the participants' sample technical mean energy savings estimates (X_{pt}) and standard deviation (S_{pt})
6. Conduct a pre-and post-program impact analysis on the sample using individual participant data, such as billing or audit data
7. Calculate the participants sample's actual mean energy savings (X_{pa}) and standard deviation (S_{pa})
8. Construct a confidence interval for the difference between the means, **Confidence Interval = $(X_{pt}-X_{pa}) \pm$ absolute error,**
9. If there is no statistical difference between the means, then use μe.
10. If there is a statistical difference, it is necessary to adjust the participants' technical mean energy savings (μe)
11. Use the ratio technique to adjust the μe and calculate adjusted mean energy savings (μa)
12. Calculate the Adjusted Energy Savings (AES) impacts by multiplying the adjusted mean energy savings (μa) by the number of participants (N).

The ratio adjustment process requires an explanation. If we find the sample's actual mean energy savings (X_{pa}) is different from the sample's technical mean energy savings (X_{pt}), then we need to adjust the μe to reflect this and recalculate the energy savings.

X_{pa} is the actual value of the participants mean energy savings, and X_{pt} is the technical estimate of participants mean energy savings. The ratio method uses the sample to estimate the relative difference between the technically estimated and the realized energy savings. The estimated relative change (X_{pa}/X_{pt}) is multiplied by the estimated mean energy savings (μe) to obtain the adjusted Participant's mean energy savings (μa). The adjusted participant's mean energy savings is multiplied by the number of participants (N) to calculate the adjusted energy savings (AES) derived from the program. This procedure provides an increase in precision by taking advantage of the correlation between X_{pa} and X_{pt}.[24] Mathematically, this is expressed as:

$$\mu a = \mu e\,(X_{pa}/X_{pt})$$

This provides us with the adjustment mechanism that corrects for the engineering method technique's over-estimation bias.

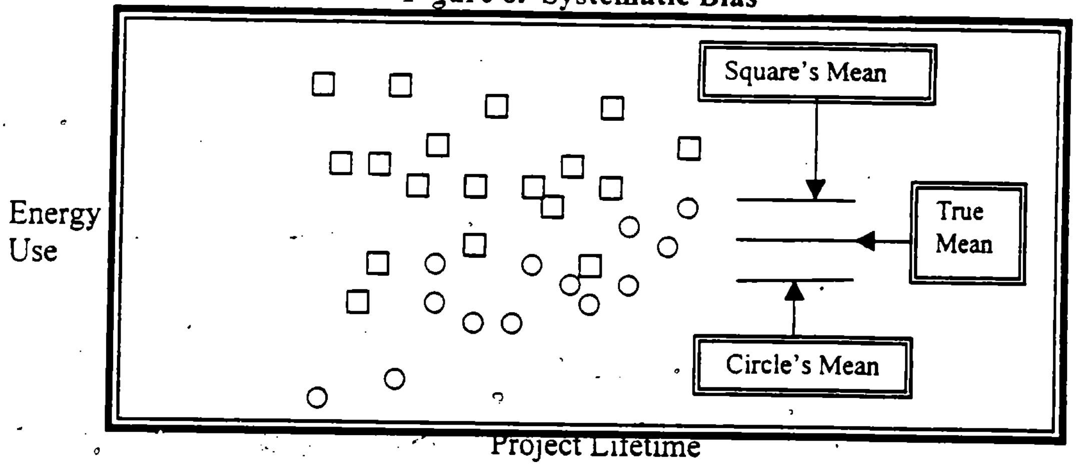
5. Self-Selection Bias

Self-selection bias (SSB) encompasses a number of potential biases including free ridership. To estimate the actual energy savings impact, it is necessary to separate the SSB from the adjusted energy savings impact (AES). Self-selection bias includes other behavioral traits of the participants that influence energy consumption. For example, a company may be energy conscious and systematically consume less energy. Moreover,

[24] William G. Cochran. (1977). *Sampling Techniques.* Third Edition. Santa Barbara: John Wiley & Sons. pp. 150-151

the energy-conscious company may have a proclivity to participate in energy-efficiency-based programs. Self-selection bias would result if a disproportionate number of energy-conscious companies participated. Figure 6, illustrates the energy use over a project's lifetime. The companies indicated by circles systematically consume less energy than the companies denoted by squares.

Figure 6. Systematic Bias



Let a majority of circles participate in a project. A disproportionate amount of circles, choosing to participate in a program, would bias the estimate on energy use. The mean of the energy use would systematically move toward the circle mean and away from the true mean.[25] The program would have a SSB and a disproportionately low energy use. Thus, the representative statistics would not be characteristic of the energy usage of the population. There would be a downward bias in any program analysis. This situation would make statistical inferences questionable. Thus, the removal of self-selection bias improves the capability of obtaining unbiased estimates representative of the population.

To correct for self-selection bias, the analyst needs to construct an analytical device that removes the SSB from the participants' adjusted energy savings impact. In essence, what the analyst is doing is constructing a series of impact estimates that show what the impact of the program would be if the program consisted entirely of non-participants. As non-participants are not predisposed towards the program goals, the self-selection bias effects are removed. SSB can be removed by executing the following 10 steps.

<u>10 Steps for Self-Selection Bias Removal</u>

1. Assemble the proper database
2. Calculate the adjusted participant's mean energy savings (μa[26])
3. Select a random or equal probability of being selected sample of non-participants (n_{np})

[25] The opposite would be true if the squares systematically dominated a project.

[26] Note: μa equals μe if the sample and the population means are not statistically different.

4. Calculate the non-participants sample's actual energy changes (x_{np})
5. Calculate the non-participants sample mean (X_{np}) and standard deviation (S_{np})
6. Regress the non-participants sample's actual energy changes (x_{np}), against a series of independent variables (v_i), such that,
   $x_i = \beta_1 v_{1i} + \beta_2 v_{2i} + \ldots + \beta_n v_{ni} + \varepsilon_i$.[27]
7. Construct a new variable y_p where, $y_i = \beta_1 v_{1i} + \beta_2 v_{2i} + \ldots + \beta_n v_{ni} + \varepsilon_i$.[28] It is important that the βs are the same as in step 5, and v's are corresponding data[29] collected from the participants' group,
8. Calculate the pseudo non-participants sample mean (Y_{np}) and standard deviation (S_{yp})
9. Subtract the pseudo non-participants sample mean (Y_{np}) from the adjusted participant's mean energy savings (μa), to obtain the average amount of savings you can attribute to the program (μ)
   $\mu = \mu a - Y_{np}$
10. Calculate the Participants Energy Saving (PES) by multiplying the mean energy savings (μ) by the number of participants (N). **PES = μ*N**

The resulting PES has corrected (1) the upward bias in the energy saving estimate from the engineering and (2) the self-selection bias. Thus, PES is an unbiased[30] estimate of the EPA programs' energy savings on the programs' participants. However, PES is not totally inclusive of all EPA energy-saving-impacts. PES does not allow for the inclusion of attributable, positive, and EPA program-related impacts on non-participants.

6. EPA Program-Related Impacts on Non-Participants

Program-related impacts on non-participants occur when individuals, responding to EPA outreach vehicles, perform program actions without requiring or receiving full benefits offered through program participation. It is important to note that the Green Lights and ENERGY STAR Buildings program designs are fundamentally publicity oriented. Moreover, they provide unrestricted free access to information. Thus, Green Lights and ENERGY STAR Buildings actively encourage sharing and "partial participation." In fact, they aim to maximize program-related impacts on non-participants. For example, there are no restrictions on non-partners accessing and using many EPA program tools or attending EPA-sponsored workshops. As a result, these activities may positively influence, induce, or guide the non-partner through an energy upgrade project.

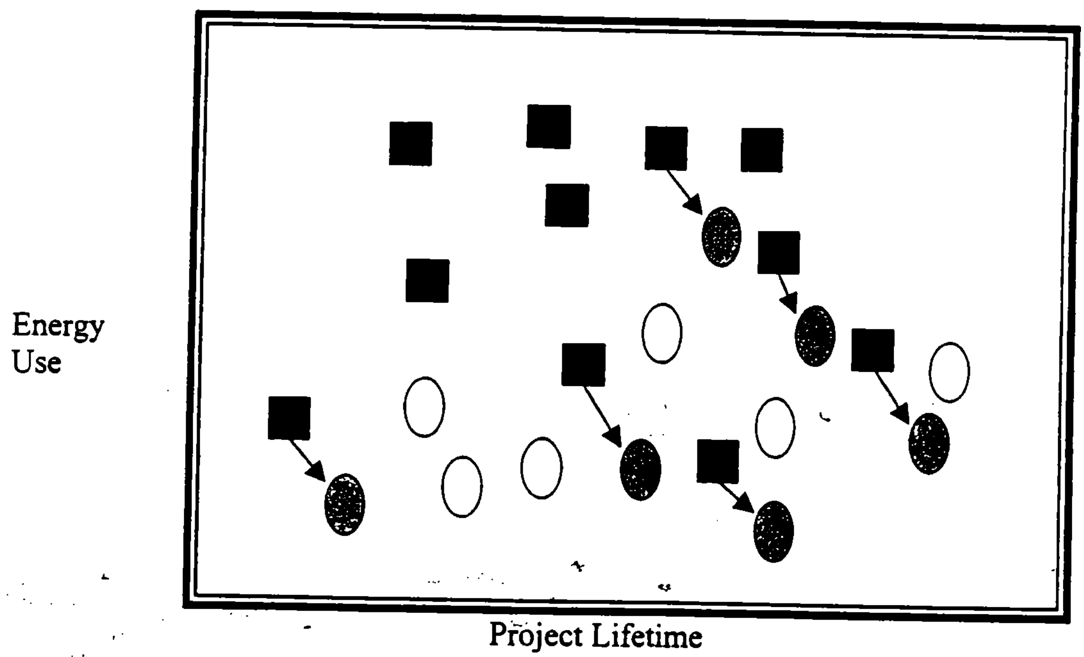
---

[27] It is important that the v's used in the regression equation on non-participant group's energy savings also are known for the participant group. N.B. It is essential that one of the v independent variables be a binary indicator of participation in an utility DSM or other energy-efficiency program.
[28] Note: Energy savings are first differences by definition. Consequently, the usual constant term is removed form the regression equation.
[29] For example, if v_1 represents non-participant's square footage in the non-participants equation, then it must represent the participant's square footage in the y calculation.
[30] Unbiased in terms of engineering method overstatements and self-selection bias.

A company that conducts an energy-efficiency project because of an EPA-sponsored activity, but that does not join either the Green Lights and Energy Star Buildings program, is a free driver. Free drivership allows organizations to receive many of the program benefits without having to file progress reports. The reporting requirement of the Green Lights and Energy Star Building program might contribute to the incidence of free-drivership.

Given EPA's focus on public awareness of its programs, it is reasonable to propose that some companies have been informed and motivated by EPA outreach efforts. Moreover, those companies, while engaging in the Green Lights and Energy Star Buildings Program's suggested activities might not have signed a memorandum of understanding (MOU) with EPA. Consequently, they have been EPA program-influenced, but are not program participants. Thus, there has been a program-related impact on non-participants, but this impact has gone unmeasured and has not been attributed to EPA's program. Rather than calling them free drivers, we refer to these companies as partial-participants. Partial-participants activity is illustrated in Figure 7. The non-participants are black squares, the participants are white ovals, and the partial-participants are black squares changing into gray ovals.

Figure 7. Partial Participants



The partial-participants may have attended EPA activities and/or obtained EPA materials and handbooks. As a result, the partial-participants alter their energy-use habits from non-participant-like (black square), to behavior similar to participants (gray oval). Thus, in the end, they possess similar program participant-like energy-use characteristics. Their impact, however, is not being counted among EPA's program successes.

Partial-participants are defined as companies that are: 1) influenced by EPA program-related sponsored events, are 2) non-participants in any EPA program, but are 3) actively pursuing the Green Lights and Energy Star Buildings Program's suggested activities nevertheless[31].

The calculation of the partial-participant's energy savings proceeds in a fashion similar to the estimation of SSB. There is an important difference. It will be necessary to "capture" the partial-participants. Aspen will work with EPA to collect information on potential partial-participants. Potential sources include conference attendee lists, EPA contact information, and web-site hits etc. From this information, a sample will be drawn and the analysis conducted. The following nine steps are the anticipated approach.

<u>10-Step Partial-Participant Estimate Approach</u>

1. Assemble the proper database
2. Select a random or equal probability of being selected sample of partial-participants (n_{pp})
3. Calculate the partial-participants sample's energy savings (x_{pp})
4. Calculate the partial-participants sample mean (X_{pp}), and standard deviation (S_{np})
5. Collect the information obtained in the SSB elimination procedure
6. Regress the non-participants sample's energy changes (x_{np}), against a series of independent variables (v_i), such that, $\mathbf{x_i} = \alpha + \beta_1 v_{1i} + \beta_2 v_{2i} + \ldots + \beta_n v_{ni} + \varepsilon_i$.[32]
7. Construct a new variable y_{pp} where, $y_i = \alpha + \beta_1 v_{1i} + \beta_2 v_{2i} + \ldots + \beta_n v_{ni} + \varepsilon_i$. It is important that the βs are the same as in step 5, and v's are corresponding data[33] collected from the partial-participant's group
8. Calculate the pseudo non-participants sample mean (Y_{pp}) and standard deviation (S_{ypp})
9. Subtract the non-participant's mean energy changes (X_{np}) from the pseudo partial-participants sample's mean energy savings (Y_{pp}), to obtain the average amount of savings you can attribute to the program, $\mu_{pp} = \mathbf{Y_{pp} - X_{np}}$
10. Calculate the partial-participant's energy saving (PPES) impacts by multiplying the mean energy savings (μ_{pp}) times the number of partial-participants (N_{pp}). **PPES = (μ_{pp}) (N_{pp}).**

---

[31] Partial participants are also known as free drivers.

[32] It is important that the v's used in the regression equation on partial-participant group's energy savings also are known for the participant group. N.B. It is essential that one of the v independent variables be a binary indicator of participation in an utility DSM or other energy efficiency program.

[33] For example, if v_1 represents non-participant's square footage in the non-participants equation, then it must represent the participant's square footage in the y calculation.

7. Market Transformation

Market transformation represents a fundamental and permanent shift in consumer behavior resulting from a program[34]. Markets are fluid. In some instances, markets are weakly chaotic. Market transformations when there is an impact or penetration of a program or a technology. There are a number of ways to measure the impact of market penetration of new energy technologies[35]. At the most basic level, one can examine the penetration and maturation of a technology, or can view the market in toto and analyze the change in the market's frequency distributions. The examination of the degree of market transformation attributable to a successful addresses a structural change in the market.

7a. Market Transformation – Changes in Market Frequency Distributions

One way of measuring market transformation is that, after a market transformation, the distribution of the energy use characteristics of is different than before the program was implemented. Using a proper baseline, the difference in the two markets states can be measured. If the EPA's program is the sole source of change, then the amount of energy savings created by market transformation can be attributed to the program.

To illustrate this, let the Before-Program market contain a set of industries with a distribution of devices, system designs, and/or operation behaviors with varying associated energy efficiencies. This distribution possesses a mean and variance. A program is implemented and its impact is felt on the market. The After-Program (i.e., transformed market) will also have a distribution of varying energy efficiencies, possessing a mean and variance. The transformed market's mean, however, denotes a range of energy-consuming products containing higher efficiencies and/or better operating characteristics.

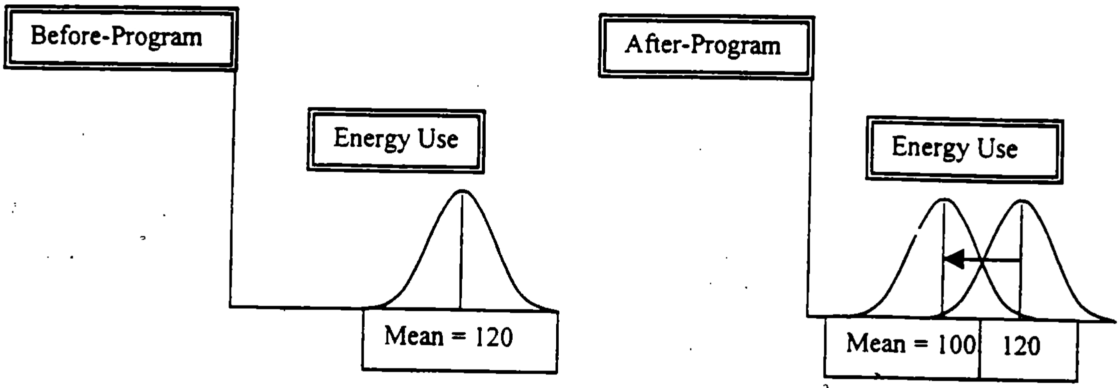
In essence, the effective energy-use distribution of relevant products in the market has shifted in the direction of higher efficiency. Effective energy-use distribution is used here because we do not want to rule out optimal system design and operation as an energy-efficiency project goal or market transformation program. In this first section, there are three market transformation cases. The first scenario (mean-changing market transformation) is illustrated in Figure 8.

---

[34] Scott Albert (1998) Navigating Market Transformations through New England's Minefield of Deregulation. In *1998 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings*. Volume 7: Market Transformation. p. 7.1

[35] See Daniel J. Packey (February 1993). *Market Penetration of New Energy Technologies*. NREL/TP-462-4860. Golden: National Renewable Energy Laboratory.

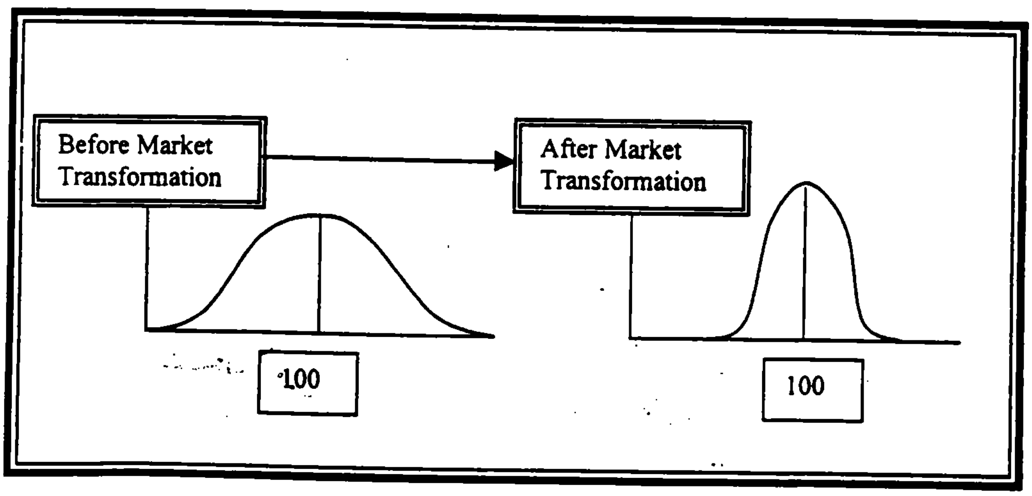
Figure 8. Mean-Changing Market Transformation



The After-Program market has shifted to the left. The variance is the same but the mean has decreased from 120 to 100. This form of market transformation is called a mean-changing market transformation. In this example, the average energy efficiency has improved in the market (i.e., average energy consumption has decreased). [36] The distribution of technologies has shifted left reflecting a structural change in the market. Figure 8, illustrates the situation in which the market has recognized the value of a certain product's characteristic, (in this example energy efficiency) and responded to it by making the entire product line more efficient. If this market recognition is the by-product of a program, then this form of market transformation can be attributed to that program.

There is also a variance-changing market transformation. In a variance-changing market transformation, the mean stays the same but the variance changes. Figure 9 illustrates this by showing that the After-Program market transformation variance (σ^2_{ap}) is less than the Before-Program market transformation variance (σ^2_{bp}) (i.e., $\sigma^2_{ap} < \sigma^2_{bp}$).

Figure 9. Variance-Changing Market Transformation

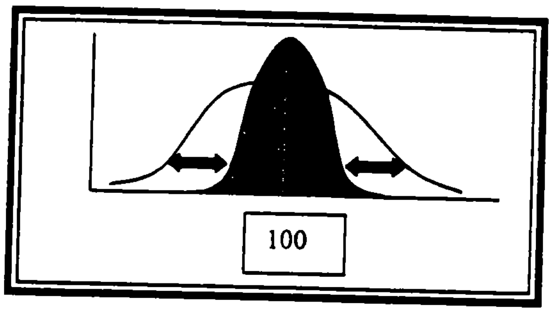


[36] This assumes the same services are being provided and only the energy consumption characteristics of the products have decreased.

Market transformation can be interpreted here as reducing the amount of far-flung options or outliers. The variance has been reduced; the observations are positioned nearer to the mean in the After-Program market transformation graph. This implies a change in the market such that the average person's energy consumption more closely approximates the mean energy consumption of 100. Outliers have been reduced and energy consumption is more predictable (i.e., less variance in the market). This result could occur in programs in which incentives are paid to individuals for consumption of products that approximate (some value ± a certain percent) a desired characteristic.

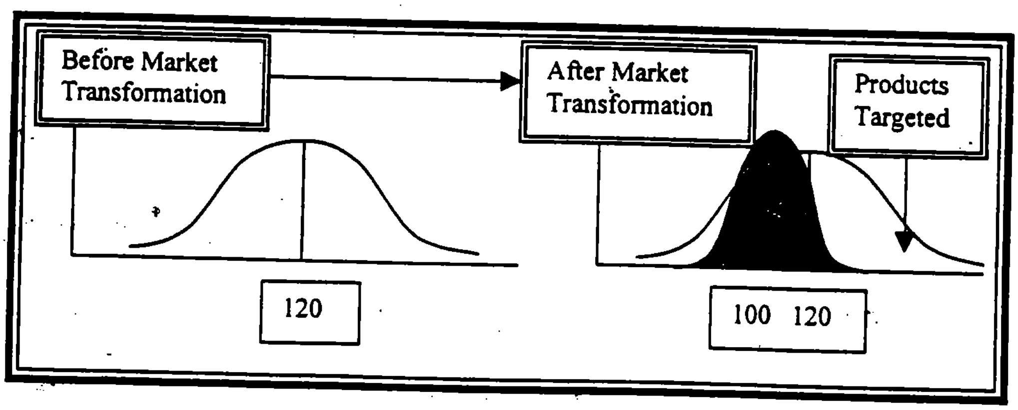
Figure 10, combines the two graphs shown in figure 9 illustrating the market transformation. Note that the After-Program market transformation graph fits within the outer tails of the Before-Program distribution.[37] The variance is less as the market responds in its efforts to consume products with usage characteristics close to the mean or designated value.

Figure 10. Variance-Changing Market Transformation



The third type of market transformation is a mean- and variance-changing market transformation. In essence, the third type of market transformation is a combination of the first two types. The mean- and variance-changing market transformation is illustrated in figure 11.

Figure 11. Mean- and Variance-Changing Market Transformation



[37] Although it should be noted that the frequency of occurrence at the mean is higher.

Here is a program that interacts with the market, such that the mean decreases and the variance is smaller. The mean- and variance-changing market transformation could result from a program targeted at the elimination of products in one tail of the distribution. For example, three effects would result from an energy-efficiency program targeted to eliminate grossly inefficient appliances. First, the products would cease to be produced. Second, with the removal from the market of the inefficient products, the market's mean would shift, indicating a more efficient market. Finally, as the outliers were removed, the distribution would concentrate around the new mean.

The first and the third market transformation scenarios create the highest interest. These denote clear measurable market savings,[38] as market savings can be viewed in energy-efficiency market improvement. Thus, the evaluation will focus on the first and third types of market transformation. Aspen has conducted this type of market transformation analysis for air conditioner and refrigerator incentive programs.[39] Aspen anticipates that a similar type of analysis will be employed in this market transformation evaluation. The analytical process will proceed as follows:

<u>Five Steps in Estimating Market Transformation Impacts</u>

1. Determine the baseline distribution (μ_b and σ_b^2) for the appropriate market
2. Determine the transformed distribution (μ_t and σ_t^2) for the same market
3. Compare the transformed market with the original market and calculate market impact in terms of changed mean and variance ($\Delta\mu$ and $\Delta\sigma^2$).
4. Calculate energy savings implied by market transformation.
5. Estimate the proportion of energy savings attributable to the programs.

The analysis is composed of two major tasks. The first major analytical task is to estimate the degree or amount of energy efficiency market transformation that exists in the market. The second task of the analysis will be to address the apportionment of the market transformation to EPA and other market-based energy efficiency programs.

7b. New Technology Market Penetration Viewed as Market Transformation

Diffusion models are a major tool used in modeling market penetration. Diffusion models estimate the degree of entry of a new (or improved) technology (or product) into the marketplace. As a rule, diffusion models (e.g., Bass, 1969; Fourt and Woodlock, 1960; Mansfield, 1961; Blackman, 1974; Fisher and Pry, 1971; Kalish, 1981; and Kalish and Lilien, 1986) address two market participants: innovators and imitators.[40]

Innovators are market pioneers. They are the first to adopt new technologies or products. Innovators are not influenced by previous adopters but by some outside

[38] Variance changing market transformation was presented for completeness.
[39] Aspen System Corporation. (1995). *Impact Evaluation of Con Edison's Residential Enlightened Energy Programs. Final Technical Report.* Silver Springs: Aspen System Corporation.
[40] Daniel J. Packey. (February 1993). *Market Penetration of New Energy Technologies.* NREL/TP-462-4860. Golden: National Renewable Energy Laboratory. P. 18.

external agent.[41] Previous purchasers of a product influence the imitators. The imitator segment first starts smaller than the innovator segment and then swells to a greater size.[42] Innovators are influenced externally (e.g., mass media communications, Websites) and imitators are affected internally (i.e., by word-of-mouth communications) from those who have already purchased the product.[43] The diffusion model implicitly assumes an information transfer between innovators and imitators.[44]

The Bass model (1969) is the generalized form of a diffusion model. The basic diffusion model can be expressed as:

$$\mathbf{n(t) = dN(t)/dt = p[M - N(t)] + (q/M)\,N(t)[M - N(t)]}$$

Where:

n(t)	=	number of adopters at time t
N(t)	=	the cumulative number of adopters
M	=	the ultimate number of adopters
p	=	adoptive influence independent of prior adoptions
q	=	adoptive influence dependent on imitation or learning

The innovators are represented by the term **p[M – N(t)]**. Imitators are denoted by **(q/M) N(t)[M – N(t)]**. The coefficient of innovation and the coefficient of imitation are p and q. These are typically assumed to be constants, with an initial pM level of purchasers.[45] This commonly traces out an "S"-shaped cumulative adoption function. Discussions of sigmoid functions, points of inflections and symmetry can be mystifying and obtuse. Figure 12, presents adoption patterns in a diffusion model. Figure 12 is divided into two areas: (1) the amount of adoption attributed to innovators, and (2) the amount of adoption attributed to imitators.

---

[41] A common example of an outside agent is advertising.

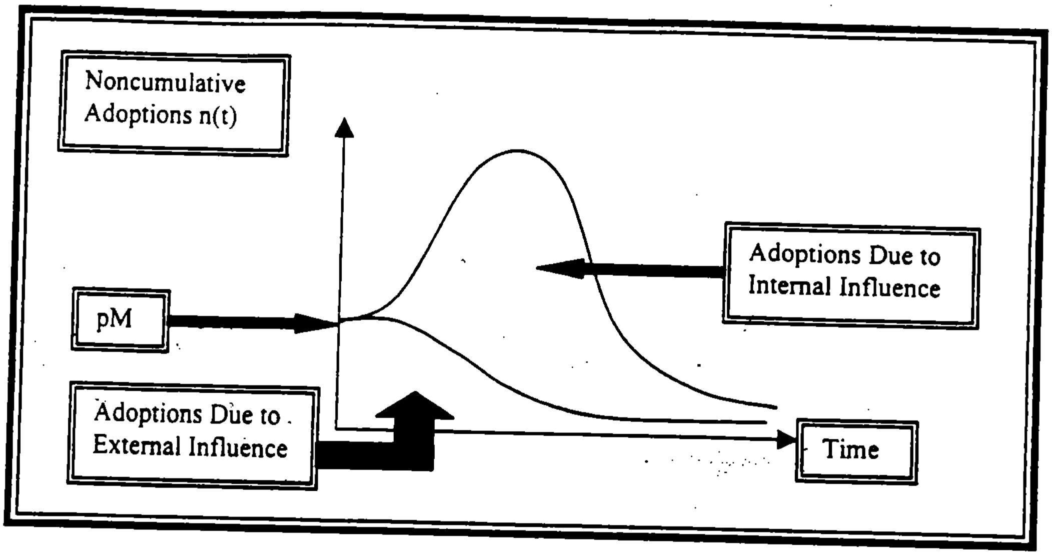
[42] A.P.S. Teotia and P.S. Rau (1986). Forecasting the Market Penetration of New Technologies Using a Combination of Economic Cost and Diffusion Models. *Journal of Product Innovation Management.* Vol. 4. Pp. 225-237.

[43] Per Lekvall and Clas Wahlbin. (1973). A Study of Some Assumptions Underlying Innovation Diffusion Functions. *Swedish Journal of Economics.* Vol. 75. Pp. 362-377.

[44] A.P.S. Teotia and P.S. Rau (1986). Forecasting the Market Penetration of New Technologies Using a Combination of Economic Cost and Diffusion Models. *Journal of Product Innovation Management.* Vol. 4. Pp. 225-237.

[45] Daniel J. Packey. (February 1993). *Market Penetration of New Energy Technologies.* NREL/TP-462-4860. Golden: National Renewable Energy Laboratory. P. 19.

Figure 12. Adoption Patterns in a Diffusion Model



Diffusion models are more applicably used on a particular technology or product. If a program is applied to a particular technology or product, then a diffusion model can be used to estimate the market transformation impacts. There are five steps in accomplishing this task.

<u>Five Steps To Estimate Market Transformation Impacts – Diffusion Approach</u>

1. Determine the baseline for the appropriate market
2. Determine the program's diffusion impact on the new technology or product penetration in the same market
3. Compare the transformed market to the original market and calculate market impact in terms of changed entry effects of innovators and accelerated imitators
4. Calculate energy savings implied by market transformation
5. Estimate the proportion of energy savings attributable to the program

The diffusion model approach will require a forecasted baseline. Thus, this approach is actually a hybrid. The first step produces an estimated market without program impacts. This step will probably involve econometric analysis. It is anticipated that the econometric analysis will be of a similar nature to those used in the non-participants, self-selection bias, and partial-participants estimation procedures discussed previously. The second step calculates the program impacts on the market through its influences on innovators and imitators. The following three steps are similar to the changes in the distribution in the market approach presented earlier.

8. Calculating the Green Lights and Energy Star Buildings Program Energy Impact Estimate

The calculation of the Green Lights and Energy Star Buildings Program's Energy Impact Estimate combines the results of the four previous estimating procedures. The initial technical estimated energy savings (TES) is adjusted[46]using the ratio technique to obtain the adjusted energy savings (AES). The AES is then corrected for self-selection bias to calculate the participants' energy savings impact (PES). The PES is added to the partial-participants energy-savings (PPES) and the resulting total represents company-based energy savings. The company-based energy savings is added to EPA's Green Lights and Energy Star Buildings market transformation impacts to arrive at an EPA-attributed energy-saving's (ES) impact estimate.

Thus far we have only addressed electricity savings from the Green Lights program. As Energy Star Buildings gains momentum, however, it will be necessary to track the energy savings impacts not only for electricity, but also for natural gas, oil, steam, and other fuels as well. The tracking approaches selected need to be flexible enough to account for the incorporation of these additional fuel types.

9. Data Requirements, Sampling Needs and OMB Clearance

Whenever possible, Aspen will use available data sources. It is anticipated that Strategic Tracking and Recruitment (STAR) (formerly EPA's Marketing Information DataBase MIDB) will be used extensively. The underlying makeup of STAR will be reviewed for analytical purposes. Aspen may need expanded access to the MIDB AND STAR. The Commercial Building Energy Consumption Survey (CBECS) will be examined to determine if it can be used. The accuracy of CBECS is acceptable; however, CBECS will have to be reviewed for possible contamination. If CBECS is acceptable for use in evaluation, Aspen will use it where appropriate. Under acceptable conditions, the information found in CBECS could be very useful in estimating non-participant parameters.

Samples of participants in the Green Lights and ENERGY STAR Buildings programs will be selected. There is a temporal element in the Green Lights and ENERGY STAR Buildings Program. A Partner may control many buildings. In any given year, the Partner upgrades some of them. The Partner has seven years to complete the process. Thus, files will be reviewed for completeness. Contact with participants may be necessary if files are incomplete or if additional data is required. Those participants that have reported the information necessary for the SSB cleaning procedure will not be contacted. Samples of non-participants and partial-participants will be needed. To estimate the cumulative impacts since the program's inception, the study period should include the entire program life. Sampling techniques that allow for reduced sample sizes will be used where appropriate.[47]

[46] ES is adjusted only if found to possess a systematic bias.
[47] For example, stratified sampling or cluster sampling could be used if the situation permits.

By the nature and definition of partial-participant,[48] it will be necessary to sample and contact the partial-participant directly. EPA contact, workshop, Web site hits and other information will be needed to construct a sampling frame and to estimate population size. It is anticipated that OMB clearance will be required for data collection to support impact evaluation.

The market transformation study will require energy use characteristics program-related products on a national level for both current and pre-program time periods. It will be necessary to estimate frequency distributions of market sales. In addition, the existence of utility lighting programs and their impacts on market transformation will have to be examined.

10. Summary

The purpose of the Aspen scoping study was to systematically develop an accurate,[49] statistically defensible evaluation methodology for the Green Lights and ENERGY STAR Buildings Program's Energy Evaluation. This is a Phase I evaluation scoping study to lay the preliminary theoretical and statistical ground work for the more detailed Phase II study. In Phase I Aspen (a) presented the formal approach for impact measurement of the 2308 Green Lights and ENERGY STAR Buildings participants and adjustments, (b) developed a statistically acceptable, systematic approach for the elimination of self-selection bias,[50] (c) discussed a methodology that allowed for the estimation of attributable, positive, and EPA program-related impacts on non-participants,[51] (d) discussed market transformation issues, impacts, and analysis, (e) indicated what was required to calculate the total EPA program-related impacts, and (f) discussed data requirements, sampling needs, and OMB clearance.

Aspen will use the evaluation methodology developed in this paper to remove any existing Green Lights and ENERGY STAR Buildings technical[52] energy-savings estimate biases. Aspen will use the ratio method to estimate the relative difference between the technically estimated and the realized energy savings. The estimated relative ratio between the sample mean and the estimated technical mean will be used to adjust the population's estimated mean energy savings. This procedure will increase precision by taking advantage of the correlation between technically estimated and the realized energy savings.[53]

[48] Partial-participants do not fill out EPA reporting forms.

[49] Aspen will work with EPA staff to determine the level of accuracy necessary to make the evaluation, statistical, and analytical methods useful for EPA reporting purposes.

[50] RCG/Hagler Bailly, Inc. (February 1991). Impact Evaluation of Demand0Side Management Programs: Volume 1: A Guide to Current Practice. EPRI CU-7179, volume 1, project 2548-11. Pp. 2-31

[51] This program impact is also known as free drivers.

[52] Technical energy savings estimates are those estimates that are based solely on engineering estimates of energy use. Technical energy savings estimates are those estimates that are based solely on engineering estimates of energy use. (Whereas, realized energy savings are those shown to have actually occurred.)

[53] William G. Cochran. (1977). *Sampling Techniques*. Third Edition. Santa Barbara: John Wiley & Sons. pp. 150-151

Given the voluntary nature of the Green Lights and ENERGY STAR Buildings Program's participants, Aspen will test fo. -elf-selection bias (SSB) and will remove self-selection bias from the energy savings estimate. Self-selection bias is an encompassing term for a variety of biases. It only for free riders, but other biases as well.

Some companies are positively influenced by EPA program activities and perform program actions without becoming full program participants. These companies known as partial-participants or free drivers experience energy savings as a result of the influence of the EPA programs. Consequently, Aspen will estimate the partial-participants' increase in energy-savings and will attribute the appropriate proportion of energy-savings to the Green Lights and ENERGY STAR Buildings Program's activities.

In this scoping study we examined two types of market transformation analysis. First, the market transformation analysis discussed was one that examined the change in the energy-use/efficiency distribution in a market. Second, we looked at diffusion methods that address the market penetration of a new technology. The first approach looks at an overall market general transformation. The second approach is more appropriate for market transformation of a particular technology or specific market. In Phase II Aspen will work with EPA to select the best approach for EPA's needs.

After all of the estimates have been calculated, and reviewed for reasonableness, Aspen will be combine them to produce an unbiased energy-savings impact estimate. The resulting total will represent a Green Lights and ENERGY STAR Buildings energy impact estimate. The energy savings estimates thus estimated will be based on a consistent, statistically defensible evaluation methodology.

Given the necessity of obtaining information from non-participants and partial-participants, OMB clearance for data collection will be necessary.

11. References

Albert, Scott. (1998). Navigating Market Transformations through New England's Minefield of Deregulation. In *1998 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings*. Vol. 7: Market Transformation. Washington, DC: American Council for an Energy Efficient Economy.

Bass, Frank M. (1969). A New Product Growth Model for Consumer Durables. *Management Science*. Vol. 15. 215-227.

Bass, Frank M. (1980). The Relationship Between Diffusion Rates, Experience Curve, and Demand Elasticities for Consume Durable technological Innovations. *Journal of Business*. Vol. 53. S51-S67.

Blackman, A. Wade Jr. (1974). The Market Dynamics of Technological Substitutions. *Technological Forecasting and Social Change*. Vol. 6. 41-63.

Blumstein, Carl, Seymore Goldstone, and Loren Lutzenhiser. (1998). A Theory-based Approach to Market Transformation. In *1998 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings*. Vol. 7: Market Transformation. Washington, D.C.: American Council for an Energy Efficient Economy.

Beals, Ralph E., (1972). *Statistics for Economists*. Chicago: Rand McNally.

Cochran, William G. (1977). *Sampling Techniques*. Third Edition. Santa Barbara: John Wiley & Sons.

Fisher, J. C., and R. H. Pry. (1971). A Simple Substitution Model of Technological Change. *Technological Forecasting and Social Change*. Vol. 3. 75-88.

Fourts, Louis A., and Joseph W. Woodlock. (1960). Early Prediction of Market Success for New Grocery Products. *Journal of Marketing*. Vol. 25. 31-38.

Kalish, Shlomo. (1985). A New Product Adoption Model With Pricing Advertising and Uncertainty. *Management Science*. Vol. 31. 1569-1585.

Kalish, Shlomo, and Gary L. Lilian. (1986). A Market Entry Timing Model for New Technologies. *Management Science*. Vol. 32. 194-205.

Kish, Leslie. (1965). *Survey Sampling*. New York: John Wiley and Sons.

Lekvall, Per and Clas Wahlbin. (1973). A Study of Some Assumptions Underlying Innovation Diffusion Functions. *Swedish Journal of Economics*. Vol. 75. 362-377.

Mood, Alexander M., Franklin A. Graybill, and Duane C. Boes. (1974). *Introduction to the Theory of Statistics.* Third Edition. New York: McGraw-Hil'

Packey, Daniel J. (February 1993). *Market Penetration of New Energy Technologies.* NREL/TP-462-4860. Golden: National Renewable Energy Laboratory.

RCG/Hagler Bailly, Inc. (February 1991). *Impact Evaluation of Demand-Side Management Programs: Volume 1: A Guide to Current Practice.* EPRI CU-7179, Vol. 1, project 2548-11.

Teotia, A.P.S. and P.S. Rau (1986). Forecasting the Market Penetration of New Technologies Using a Combination of Economic Cost and Diffusion Models. *Journal of Product Innovation Management.* Vol. 4. 225-237.

United States Department of Energy (December 1997). *IPMVP International Performance Measurement and Verification Protocol:* Expanded Version of 1996 North American Energy Measurement and Verification Protocol. DOE/EE-0157. Washington, DC.

United States Environmental Protection Agency. (May 1997). *Building On Our Success: Green Lights and ENERGY STAR Buildings 1996 Year in Review.* EPA 430-R-97-002. Washington, DC: EPA.

United States Environmental Protection Agency (April 1998). *Building On Our Success: ENERGY STAR Buildings and Green Lights 1997 Year in Review.* EPA 430-R-98-001. Washington, DC: EPA.

Western Area Power Administration and Southwestern Power Administration. (December 1994). *DSM Evaluation Guidebook Part 1: Developing a DSM Baseline.* NREL/SP-462-5859 DE94011806, Golden: National Renewable Energy Laboratory.

12. Appendix A: EPA ENERGY STAR Buildings Agreement Information

...ndersigned hereby execute this Memorandum of Understand... ...'s agree... ...ms that they have the authority (actual or delegated) to commit PARTNER and the facilities included hereunder to particip... ...e ENERGY STAR BUILDINGS Partnership. This Memorandum takes effect when signed by both parties.
...ase supply the following information with the signed MOU:

...PARTNER:	For U.S. EPA:
...gnature	Paul Stolpman
...tle	Director, Office of Atmospheric Programs
...ate	Date

...ase supply the following information with the signed MOU:

...hief Executive Officer's Name	Title
...ddress	Phone/Fax Number
...ity/State/Zip	E-mail Address

...ERGY STAR BUILDINGS ...ergy Strategy Director:	ENERGY STAR BUILDINGS Communications Director:
...r./Ms.	Mr./Ms.
...itle	Title
...ddress	Address
...ity/State/Zip	City/State/Zip
...hone/Fax	Phone/Fax
...-mail	E-mail

...IC Code or Nature of Business

...pproximate total square footage of organization:

Education	Lodging	Manufacturing/Industrial	Warehouse
Healthcare	Office	Retail	Other

...the organization signing this MOU a component of another organization? ❑ yes ❑ no

...o, please provide the name of the parent organization:

...hat is the first day of your organization's next fiscal year?

...ho referred you to ENERGY STAR BUILDINGS?

Please return: (1) the signed MOU in its entirety, and (2) a camera-ready version of your organization's logo to:
Director, ENERGY STAR BUILDINGS
US Environmental Protection Agency (6202J)
401 M Street, SW, Washington, D.C. 20460
Phone: (202) 564-9230 ● Fax: (202) 565-2083 ● Hotline: (888) 782-7937

Memorandum of Understanding Between
The United States Environmental Protection Agency
and
COMPANY, an ENERGY STAR BUILDINGS℠ Partner

COMMON AGREEMENTS AND PRINCIPLES

This is a voluntary agreement between COMPANY, ("PARTNER") and the United States Environmental Protection Agency ("EPA"), by which the two parties enter EPA's ENERGY STAR BUILDINGS and GREEN LIGHTS® ("PARTNERSHIP")designed to prevent pollution through the use of a strategic energy efficient approach. Each party agrees to assume the good faith of the other party as a general principle for the PARTNERSHIP.

Either party can terminate this agreement, without penalty or liabilities to either, via 10 days' written notice to the other, and both will then cease to publicize PARTNER's participation in the PARTNERSHIP. This Memorandum of Understanding (MOU) may be terminated only by the original authorized signatory or a representative of equal or greater authority.

PARTNER AGREES TO:

Planning and Benchmarking

- Designate a Strategic Energy Director and a Communications Director upon signing this agreement.
- Conduct a kickoff meeting with assistance from EPA.
- Upgrade at least one Pilot Building within two years of the effective date of this agreement.

Use Integrated Approach

- Upgrade 60% of PARTNER's eligible facilities within 7 years, according to the PARTNERSHIP's five integrated approach to maximize energy savings to the extent that the upgrades are profitable and ma or improve productivity and worker comfort.

Communicate And Demonstrate Success

- Submit annual ENERGY STAR BUILDINGS Utility Data Report or the equivalent Electronic Progress F to EPA for completed survey or upgrade projects.

EPA AGREES TO:

Assist Partner in Planning And Benchmarking

- Designate a customer service representative (Account Manager) to assist PARTNER.
- Conduct a kickoff meeting with PARTNER.
- Provide tools to assist with benchmarking and scheduling.

Help Partner Use Integrated Approach

- Offer workshops and objective information about energy-efficient technologies and applications.
- Provide analytical tools that help PARTNER calculate potential savings from upgraded systems.
- Administer an ENERGY STAR BUILDINGS Ally Program.

Communicate Partners Success

- Develop case studies documenting monitored savings for specific facilities and technologies.
- Provide recognition for PARTNERS that show exemplary reductions in energy use including one majo event each year and public service announcements.
- Provide reproducible materials for PARTNER, upon request, to publicize PARTNER's accomplishm
- Provide educational materials to communicate results of the PARTNERSHIP within PARTNER's orgar and to the public at large.

In order to maintain consistency and fairness among participants, this MOU may not be changed.

GENERAL PROVISIONS

A. Each party's commitments will be subject to any legal restrictions that may apply. EPA agrees that information provided by PARTNER to EPA will be handled pursuant to EPA's public information regulations. Information determined Confidential Business Information by EPA will not be released to the public.

B. PARTNER and EPA agree that the GREEN LIGHTS® logo and ENERGY STAR BUILDINGS logo are marks of the United States EPA, and are subject to the provisions of Title 15, Chapter 22, United States Code, the various state laws applicable to trademarks, and this Memorandum of Understanding.

C. EPA agrees to permit PARTNER to use the ENERGY STAR BUILDINGS logo on non product-specific materials that will publicize PARTNER's participation in ENERGY STAR BUILDINGS. PARTNER's use of the ENERGY STAR BUILDINGS logo is subject to the provisions of the ENERGY STAR BUILDINGS logo use guidelines. EPA will furnish the guidelines to all PARTNERS within 60 days of signing this agreement. Where PARTNER, or its component part, is a member of the building-related products and services industry, PARTNER agrees that it will only use the ENERGY STAR BUILDINGS logo to publicize its participation with EPA in the ENERGY STAR BUILDINGS Partnership. Both parties agree that participation in ENERGY STAR BUILDINGS, use of the ENERGY STAR BUILDINGS logo, or any publicity relating to PARTNER's participation in the Partnership does not constitute EPA's endorsement of PARTNER for anything other than its commitment to implement energy-efficient facility upgrades and practices. PARTNER and EPA agree that they will neither state nor imply otherwise. PARTNER agrees not to alter the ENERGY STAR BUILDINGS logo. If either EPA or PARTNER terminates this agreement, PARTNER will no longer be entitled to apply the ENERGY STAR BUILDINGS logo to any materials, and will no longer make reference to the Partnership so as to state or imply continuing involvement in ENERGY STAR BUILDINGS.

CONTACTS (optional)

EPA publishes a monthly newsletter that provides news about events, new participants, media coverage, training opportunities, etc. We would be happy to send copies to as many people in your organization, in addition to the Implementation Director and Communications Director. Our current participants usually designate these types of subscribers: managers and executives in the public affairs, environmental, energy, facilities management (regional managers or managers of major facilities), real estate, strategic planning and corporate finance departments. Please provide names, facsimile numbers and E-mail addresses below

Name/Title	**Name/Title**	**Name/Title**
Address	**Address**	**Address**
City/State/Zip	**City/State/Zip**	**City/State/Zip**
Phone/Fax	**Phone/Fax**	**Phone/Fax**
E-mail	**E-mail**	**E-mail**
Name/Title	**Name/Title**	**Name/Title**
Address	**Address**	**Address**
City/State/Zip	**City/State/Zip**	**City/State/Zip**
Phone/Fax	**Phone/Fax**	**Phone/Fax**
E-mail	**E-mail**	**E-mail**

(E-mail addresses are preferred).

THANK YOU! WELCOME ABOARD.

Strategic Energy Director: The point of contact for the Partnership. PARTNER will ensure Strategic Energy Director has the authority, staffing and budget necessary to complete all profitable ENERGY STAR BUILDINGS upgrades.

Communications Director: The individual responsible for directing PARTNER communications efforts to ensure the organization is recognized for its environmental achievements in the ENERGY STAR BUILDINGS Partnership and to educate PARTNER employees, stockholders, and customers about the Partnership.

Kickoff Meeting: The initial meeting of the PARTNER project team with EPA or its representatives. The purpose of this meeting is to assemble all key individuals in the PARTNER organization with a stake in the PARTNERSHIP and plan facility upgrades. Key individuals include senior managers in facilities management, environmental compliance, corporate communications, finance, etc.

Pilot Building: A facility that can serve as a prototype to demonstrate the ENERGY STAR BUILDINGS five-stage integrated approach (see below). The Pilot building is a near term goal that will provide PARTNER with experience in planning, evaluating, and implementing upgrades in a single facility.

Five-Stage Integrated Approach: A flexible, step-by-step strategy for implementing comprehensive efficiency upgrades. The stages include the following:

1. Lighting (GREEN LIGHTS);
2. Building Tune-Up;
3. Other Load Reductions;
4. Fan System Upgrades;
5. Heating and Cooling Plant

The five-stage integrated approach is designed to achieve maximum energy savings at the lowest possible cost and accounts for the inter-system effects of comprehensive upgrades. Although PARTNER need not complete these stages sequentially, an important benefit of the sequential approach is that Stages 1, 2 and 3 reduce HVAC loads, which may significantly reduce the size and cost of equipment for Stages 4 and 5.

Lighting: All electrical and natural (daylit) lighting installations and systems, whether indoor or outdoor.

Eligible Facilities: For Stage 1 (GREEN LIGHTS) of the five-stage integrated strategy (see above), this includes the following domestic facilities: (1) all those owned and occupied; (2) all those leased from other parties under agreements that expire more than seven years after the effective date of this agreement; and (3) all those where the PARTNER is the majority or controlling owner and is currently leased to other parties, including facilities managed by property management firms and those of any component suborganizations (such as subsidiaries, divisions, and campuses). For Stages 2 to 5, eligible facilities hare the same as above, but they are limited to spaces which are conditioned. Facilities that the PARTNER reasonably anticipates selling sooner than seven years after the effective date of this agreement are excluded.

Profitable: A combination of energy-efficient operations and/or equipment upgrades that maximizes energy savings for a given facility while maintaining or improving worker comfort including indoor environmental quality (IAQ) and organizational productivity, and: (1) provides an annualized internal rate of return (IRR) after tax that is at least equivalent to *20 percentage points* over a period of 10 years; or alternately; (2) demonstrates a net present value (NPV) greater than zero over a 10 year period, using a discount rate of 20 percent.

IRR or NPV values may be calculated on an individual facility aggregate basis. In all cases, however, synergistic benefits of heating, ventilation and air conditioning (HVAC) load reductions on other investments should be considered in calculating rates of return. It is also recommended that labor costs be capitalized when calculating IRR or NPV.

For a short term lease, a project is defined as "profitable" when it provides a simple payback term shorter than the remaining lease. Organizations in financial distress may qualify for a different criterion.

ENERGY STAR Buildings℠ Partner MOU In Brief

ENERGY STAR Buildings℠ participants enter into a voluntary agreement by signing a Memorandum of Understanding (MOU) with EPA designed to prevent pollution through the use of a strategic energy-efficient approach. Partners agree to improve overall energy efficiency of their facilities through the implementation of a comprehensive set of profitable upgrades. EPA assists participants by providing technical and administrative assistance to ensure maximum energy savings while satisfying cost-effective criteria.

The ENERGY STAR Buildings℠ Partner agrees to:

Plan and Benchmark

- Designate a strategic energy director and a communications director.
- Conduct a kickoff meeting with EPA assistance.
- Upgrade at least one pilot building within 2 years of the effective signing date.

Use the Integrated Approach

- Upgrade 60% of eligible facilities within 7 years, according to the 5-stage integrated approach to maximize energy savings to the extent that the upgrades are profitable and maintain or improve productivity and worker comfort.

Communicate and Demonstrate Success

- Submit annual ENERGY STAR Buildings Utility Data Report or the equivalent Electronic Progress Report to EPA for completed survey or upgrade projects.

EPA agrees to:

Assist Partner in Planning and Benchmarking

- Designate a customer service representative (Account Manager) to assist the Partner.
- Conduct a kickoff meeting with the Partner.
- Provide tools to assist with benchmarking and scheduling.

Help Partner Use the Integrated Approach

- Offer workshops and objective information about energy-efficient technologies and applications.
- Provide analytical tools that help the Partner calculate potential savings from upgraded systems.
- Administer an ENERGY STAR Buildings Ally Program.

Communicate Partner Success

- Develop case studies documenting monitored savings for specific facilities and technologies.
- Provide recognition for Partners that show exemplary reductions in energy use, including public service announcements and one major media event each year.
- Provide reproducible materials for Partners, upon request, to publicize Partner accomplishments.
- Provide educational materials to communicate results of the Partnership within Partner organizations and to the public at large.

President Clinton's FY 2001 Climate Change Budget

The President's climate change package for FY 2001 totals over $4.1 billion – an increase of $760 million from the amount enacted for FY 2000. This includes $2.4 billion for programs directly aimed at combating global warming – a 43 percent increase over FY 2000 enacted levels. This includes a series of new initiatives, such as accelerated efforts to promote the development and deployment of clean energy technologies around the world; a stepped-up program to develop bioenergy and bio-based products; and a new Clean Air Partnership Fund to boost state and local efforts to reduce both greenhouse gases and ground-level air pollutants. It also includes the Climate Change Technology Initiative (CCTI), which mixes tax incentives and direct spending to spur the research, development, and deployment of energy efficient technology and renewable energy and other climate-related investments, such as R&D of highly efficient technologies for the combustion and use of coal and natural gas, weatherization, and state energy grants. The President is also proposing over $1.7 billion for the United States Global Change Research Program, to enhance our understanding of the human and natural forces that influence the Earth's climate system.

Table 1. Climate Change-Related Domestic Programs ($ in Millions)

	FY 2000 Enacted	FY 2001 Request	Change
Climate Change Solutions			
International Clean Energy Initiative	98	201	+103
Biofuels & Bioproducts Initiative	196	289	+93
Clean Air Partnership Fund	0	85	+85
Climate Change Technology Initiative--tax incentives [1]	N/A	201	+201
Climate Change Technology Initiative--investments	1,095	1,432	+337
Other Climate-Related Investments (cleaner coal & Natural gas; weatherization; state energy grants)	413	424	+11
Subtotal, Climate Solutions [2]	1,665	2,386	+721
Global Change Research Program	1,701	1,740	+39
TOTAL	3,366	4,126	+760

1 First year of a proposed five year, $4.0 billion package.

2 Subtotal excludes double counts for funds included in new initiatives and cleaner coal which are also part of the CCTI.

International Clean Energy Initiative

To accelerate the development and deployment of clean energy technologies around the world, President Clinton is proposing the International Clean Energy Initiative – a $200 million multi-agency effort (a more than 100 percent increase over FY 2000 enacted levels) to encourage open competitive markets and remove market barriers to clean energy technologies in developing and transition countries and to provide new incentives for clean energy technology innovation and export. This initiative will promote U.S. exports and create high-value jobs, and will assist countries to power their economic development while fighting air pollution and climate change.

Window of Opportunity for America and the World. Developing country energy use will overtake that of industrial countries by 2020. These energy technology markets are projected to total $4 to $5 trillion over the next 20 years and $15 to $25 trillion over the next 50 years. Developing country energy use is expected to account for three-fourths of the increase in global energy use between now and 2050.

Advanced, low-polluting energy technologies, developed and manufactured in the United States, can provide these energy services efficiently, but existing markets often do not value environmental and efficiency benefits. In addition, environmentally superior options often carry higher up-front costs, may be unfamiliar, or are perceived as more risky by decision-makers in developing countries. The initiative builds on a recent set of recommendations by the President's Committee of Advisors on Science and Technology (PCAST) and is directed at leveling the playing field between cleaner U.S. energy technologies and services and polluting alternatives.

Real Benefits At Home and Abroad. The initiative will help lay the technical and policy foundation that will allow developing and transition countries to build a clean energy future, leapfrogging past the polluting energy technologies used by the industrial countries, while building competitive markets open to U.S. firms. The goals of this initiative include:

- Doubling clean energy technology exports by 2005, creating as much as $5 billion in new export revenues for U.S. companies and as many as 100,000 new U.S. jobs.

- Cutting energy use in targeted country buildings and appliances in half through advanced building design tools and building equipment codes and standards.

- Developing integrated renewable energy technologies that have the potential to power the full range of energy services for the 2 billion people in developing countries that do not now have electricity.

- Sharply reducing sulfur, particulate, and greenhouse gas emissions by developing advanced coal-fired power plants and low-cost hydrogen fuels.

- Maximizing use of combined heat & power systems through technical and policy assistance.

- Reducing methane emissions from pipelines and other fossil sources by an amount equal to as much as 100 million metric tons of carbon per year by 2005.

- Providing technical and policy support to encourage the development of natural gas grids.

- Reducing energy use in the industrial sector through the introduction of best practice methods, including advanced sensors and controls, and energy efficient motor drive systems.

- Conducting research in nuclear energy to address cost, waste, safety, and proliferation concerns.

- Providing technical and policy assistance in support of energy sector reform that creates open, competitive markets while protecting the public interest.

Initiative Structure. This initiative will strengthen efforts to streamline current bureaucratic procedures to better assist U.S. firms wishing to invest in clean energy projects in developing and transition countries. This initiative will also encourage public-private partnerships with foreign counterparts to demonstrate clean energy technologies, drive down their cost, and facilitate private sector financing for their large-scale deployment. The initiative will employ a range of proven policy tools, including U.S. technical and policy assistance to developing countries through personnel exchanges, conducting collaborative R&D with key foreign research groups, developing integrated renewable energy, energy efficiency, and advanced fossil energy technologies and pilot projects, and providing a range of trade supports to expand clean energy exports.

The initiative's requested $100 million increase for these activities includes an additional $46 million for the Department of Energy (DOE); $30 million for the U.S. Agency for International Development; $15 million for the Export-Import Bank; $5 million for the Trade and Development Agency; and $4 million for the Department of Commerce. A $3 million increase in base programs is also requested at DOE, bringing the total increase to $103 million.

Bioenergy & Bioproducts Initiative

President Clinton's FY 2001 Budget includes $289 million to accelerate the development and use of bio-based technologies, which convert crops, trees, and other "biomass" into fuels, power, chemicals, and other products. This initiative supports the President's August 1999 Executive Order 13134 and Memorandum on Promoting Biobased Products and Bioenergy, aimed at tripling U.S. use of biobased products and bioenergy by 2010. The initiative provides an increase of more than $93 million (47 percent) over the amounts available for FY 2000, with $49 million directed towards the Department of Energy (DOE) and $44 million for stepped-up efforts at the Department of Agriculture (USDA). (Funding in DOE is also considered part of the Climate Change Technology Initiative.) In addition to this increase in R&D, the Commodity Credit Corporation will provide $100 million in FY 2000 and up to $150 million in FY 2001 and 2002 in incentive payments to encourage production of biobased fuels. The initiative will increase the viability of alternative energy sources and help meet environmental challenges like global warming, while diversifying and strengthening the rural economy.

New Economic Opportunities for a New Century. Continuing advances in forest and farm technology, molecular biology, and other areas are fueling a revolution in the use of biomass to make low-polluting products, such as:

- **transportation fuels**, like cellulosic ethanol from agricultural waste;
- **electricity**, by burning wood chips and switchgrass along with coal in existing plants and by converting paper industry wastes into fuel gases for advanced gas turbines;
- **commercial products**, such as chemicals, glues, paints, packing materials, and textiles.

Already, creative companies such as **Cargill-Dow Polymers** are making this vision a reality, recently announcing plans to build a $300 million production facility that will convert corn based sugars into plastic fibers than can be used to make products that are all natural and biodegradable.

Meeting the President's goal of tripling U.S. use of bioenergy and bioproducts will add billions in new income for farmers, producing 50,000 new, high-technology jobs in small processing plants in rural American and up to 130,000 such jobs in biopower, bioproducts, and biofuels industries.

Cleaner Energy, Cleaner Environment. Bioenergy and bioproducts can dramatically reduce greenhouse gas emissions that contribute to global warming. Since crops absorb carbon during growth, their use for energy and other applications results in near zero net carbon release. Tripling our use of bioenergy and bioproducts by 2010 will reduce annual greenhouse gas emissions by up to 100 million tons – the equivalent of taking over 70 million cars off the road.

Making Biomass Competitve With Fossil Fuels. A major goal of this initiative is to make biomass a viable competitor to fossil fuels as an energy source and chemical feedstock while protecting the environment. This goal is achievable, but it will require an unprecedented effort to support research in universities, companies, and our national laboratories. In the past few years, for example, federal research has developed techniques that greatly accelerate the production of sugars and other useful chemicals from materials like corn stover and wood. The research funded under this initiative will ensure a continuing flow of the basic innovations on which such investments can be made.

Many uses for biomass materials are possible in the near future and this initiative will support research concepts on a competitive basis. This will include support for integrated systems capable of processing feedstocks simultaneously into a variety of products such as fuels, chemicals, and electricity. Much like today's petroleum-based refineries, the mix of products from these facilities will depend on market conditions. The research aims to understand the basic chemistry of cellulose and other materials in biomass, and develop new thermal, chemical, and bio-chemical techniques for converting these materials into useful forms.

Initiative Structure. The President's August 1999 Executive Order instructs DOE, USDA, the National Science Foundation, the Environmental Protection Agency and other agencies, to work closely together in supporting the broad range of needed research and development efforts. These efforts will support research partnerships linking industry, university, and government research facilities selected on a competitive basis. Key areas of new research activity will include:

- Development of inexpensive systems to break down cellulose into low-cost sugars, allowing woody and grassy crops and agricultural waste, such as corn stalks, to take the place of high-value grain and food crops as biofuel feedstocks.
- Renewable bioproducts, using multi-disciplinary and university/industry partnerships to develop and accelerate adoption of possible "leap-frog" technologies for converting crops, trees and residues into chemical feedstocks and consumer products.
- Biopower, promoting both the integration of biomass gasification systems with modern gas-turbine/steam-turbine generation systems, and the co-firing of biomass with coal.
- Expanded Forest Service research on faster-growing trees and the use of small-diameter trees for commercial, biobased products.
- Methane gas recovery pilots to reduce greenhouse gas emissions from livestock operations and provide assistance to farmers that want to produce or market biobased products.
- Expanded Agricultural Research Service research to develop biobased materials from commodities and bioproducts, and convert biomass to energy.
- Competitive resources for research partnerships with universities, complementing the new Initiative for Future Agriculture and Food Systems announced by USDA earlier this month.

- Rural development grants to rural electric cooperatives to develop pilot projects to demonstrate the commercial viability of small-scale biomass fuel generation, grants for technical assistance for processing and marketing biobased products, and loans for facilities and operating capital for organizations engaged in biobased production activities.

Clean Air Partnership Fund

To help protect public health and ease the threat of global warming, President Clinton is proposing $85 million for the creation of a new Clean Air Partnership Fund. The Fund will provide grants to states, localities, and tribes to support efforts that achieve reductions in both greenhouse gas emissions and ground-level air pollutants. First proposed as part of last year's FY 2000 budget, the Fund will be administered by the Environmental Protection Agency under existing authority.

Integrated Pollution Control. The Fund will stimulate integrated, cost-effective pollution control strategies. It directs new resources to state, local, and tribal governments to finance projects and programs that achieve accelerated reductions in both air pollutants, such as soot, smog, and air toxics, and in greenhouse gases.

A Quicker Path to Cleaner Air. By providing new resources for projects that accelerate pollution reductions, the Fund will enable communities to achieve multi-pollutant clean air goals sooner and reduce greenhouse gas emissions at the same time.

Technological Innovation. The Fund will help spur both public and private sector innovations in next-generation pollution control technology.

A Magnet for Local Investment & Innovation. The Fund will encourage public-private partnerships to demonstrate ways to create a cleaner environment at the local level. The Fund can be used to support local revolving funds, low-interest loan programs, matching grants, and other mechanisms that will leverage the original Federal investment, greatly increasing its impact.

"Win-Win" Clean Air Projects. The Fund will support a wide range of practical projects that will mean cleaner air, reduced greenhouse gas emissions, and real savings for taxpayers and consumers. These could include projects such as building combined heat and power facilities that put waste heat to work, reducing emissions of both sulfur dioxide and carbon dioxide; retrofitting municipal buildings to make them more energy efficient, reducing pollution resulting from electricity generation; and upgrading municipal vehicle fleets to make them more fuel efficient.

Climate Change Technology Initiative: $4.0 Billion in Tax Incentives

The President is proposing a new $4.0 billion package in tax incentives over five years to help reduce greenhouse gas emissions by spurring the purchase of energy efficient products and the use of renewable energy (see Table 2). This year's CCTI tax package is $400 million greater than last year's proposed five-year package.

Table 2. CCTI Tax Incentives ($ in Millions) — **Revenue Effect**

	FY 2001	Total FY01-05
Homes and Buildings		
Provide tax credit for energy efficient building equipment	-18	-201
Provide tax credit for new energy efficient homes	- 82	-633
Provide tax credit for solar energy systems	-9	-132
Vehicles		
Extend tax credit for electric and fuel cell vehicles and provide tax credits for qualified hybrid vehicles	0	-2078
Clean Energy		
Extend tax credit for electricity produced from wind and closed-loop biomass; provide credits for open-loop biomass facilities and coal-biomass cofiring; and provide credits for methane from certain landfills	-91	-976
Industry		
Provide 15-year recovery period for distributed power property	-1	-10
TOTAL*	**-201**	**-4030**

*Totals may not add due to rounding.

HOMES AND BUILDINGS

- ***Tax credit to consumers who purchase new energy efficient homes.*** To encourage the purchase of new energy efficient homes, consumers would receive a tax credit of $1,000 for homes purchased from 2001-2003 that use at least 30 percent less energy than the standard under the 1998 International Energy Conservation Code (IECC) and a credit of $2,000 for homes purchased from 2001-2005 that use at least 50 percent less energy than the IECC standard.

- ***Tax credit for energy efficient equipment in new and existing homes or buildings.*** This credit will encourage the purchase of electric heat pump water heaters, natural gas heat pumps, and fuel cells. The credit would apply to both residential and commercial equipment. The credit would be 20 percent of the cost of the investment, subject to a cap, for equipment purchased from 2001-2004.

- ***Tax credit for solar energy systems.*** A 15 percent tax credit will encourage the purchase by consumers and businesses of solar energy systems. The maximum credit would be $2,000 for rooftop photovoltaic systems placed in service from 2001-2007 and $1,000 for solar water heating systems placed in service from 2001-2005.

VEHICLES

- ***Tax credits for electric, fuel cell, and qualified hybrid vehicles.*** Cars and light trucks (including minivans, sport utilities, and pickups) currently account for 20 percent of greenhouse gas emissions. Tax credits for electric, fuel cell, and hybrid vehicles will help to move advanced technologies from the laboratory to the highway. These technologies can significantly reduce emissions of carbon dioxide, the most prevalent greenhouse gas.

  -- **Extend the current tax credit for electric vehicles and fuel cell vehicles.** Under current law, a 10 percent credit, up to $4,000, is provided for the cost of qualified electric vehicles and fuel cell vehicles. The credit begins to phase down in 2002 and phases out in 2005. The President's proposal would extend the tax credit at its $4,000 maximum level through 2006.

  -- **Tax credits for hybrid vehicles.** The credit – available for all qualifying vehicles, including cars, minivans, sport utility vehicles, and pickup trucks – would range from $500 to $3,000 for qualified hybrid vehicles purchased from 2003-2006, depending upon the vehicle's design performance.

CLEAN ENERGY

- ***Tax credit for electricity produced from wind.*** Current law encourages the production of electricity from wind, which emits no greenhouse gases, through a tax credit of 1.5 cents per kilowatt hour (adjusted for inflation after 1992). The current tax credit covers facilities placed in service before January 1, 2002. The President proposes a 2.5-year extension of this tax credit.

- ***Tax credits for electricity produced from biomass.*** Biomass refers to trees, crops and agricultural wastes used to produce power, fuels or chemicals. This package of credits would:

  -- **Extend current "closed-loop" biomass credit.** This proposal extends for 2.5 years the current 1.5 cent per kilowatt hour tax credit (adjusted for inflation after 1992), which covers facilities placed in service before January 1, 2002.

-- **Provide credits for "open loop" biomass facilities.** This proposal expands the definition of biomass eligible for the 1.5 cent tax credit to include certain forest-related resources and agricultural and other sources for facilities placed in service from 2001-2005, and provides a 1.0 cent credit for electricity produced from 2001-2003 from facilities placed in service prior to January 1, 2001.

-- **Provide a credit for cofiring biomass and coal.** This proposal adds a 0.5 cent per kilowatt hour tax credit for electricity produced by cofiring biomass in coal plants from 2001-2005.

-- **Provide credit for methane from landfills.** This proposal adds a 1.5 cent per kilowatt hour credit for electricity produced from landfills not subject to EPA's 1996 New Source Performance Standards/Emissions Guidelines (NSPS/EG) and 1.0 cent per kilowatt hour for landfills subject to NSPS/EG. Qualified facilities would be facilities placed in service after December 31, 2000 and before January 1, 2006.

INDUSTRY

- ***15-year recovery period for distributed power property.*** The development of distributed power technologies has made it possible to generate electricity locally at dispersed industrial, commercial, and residential locations. Such technologies can be more energy efficient and generate fewer greenhouse gases than conventional generation methods. This proposal would simplify and rationalize the current depreciation system by assigning a single 15-year recovery period to distributed power property.

Climate Change Technology Initiative: $1.4 Billion for Efficient Energy and Clean Energy

The President's FY 2001 budget proposes over $1.4 billion for the research, development, and deployment of renewable energy technologies, energy efficient products and buildings that will help reduce U.S. greenhouse gas emissions. This represents a $337 million increase (30 percent) over FY 2000 spending (see Table 3). The President's proposed investment package covers the four major carbon-emitting sectors of the economy -- buildings, transportation, industry, and electricity -- as well as carbon sequestration (see Table 4). The following sections highlight selected programs in each of these areas of effort. The full agency programs extend well beyond what is described here.

Table 3. CCTI Funding by Agency ($ in Millions)

	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	Change from 2000
Energy	902	980	1,169	+189
EPA	109	103	227	+124
Housing & Urban Development	10	10	12	+2
Agriculture	0	0	24	+24
Commerce	0	2	0	-2
TOTAL*	**1,021**	**1,095**	**1,432**	**+337**

*Totals may not add due to rounding.

Table 4. CCTI Funding by Area of Activity ($ in Millions)

	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	Change from 2000
Buildings	176	194	275	+81
Transportation	285	309	382	+73
Industry	187	189	251	+62
Electricity	310	321	406	+85
Carbon Sequestration	14	30	52	+22
Management, Planning & Analysis	48	51	65	+14
TOTAL*	**1,021**	**1,095**	**1,432**	**+337**

* Totals may not add due to rounding.

BUILDINGS

- ***Partnership for Advancing Technology in Housing.*** PATH is a partnership between the Federal government and building industry to develop and deploy housing technologies to make new homes 50 percent more energy efficient and to make at least 15 million existing homes 30 percent more energy efficient within a decade. PATH has established five pilot communities in Denver, Los Angeles, Pittsburgh, and Tuscon. The program coordinates work in the Department of Housing and Urban Development, the Department of Energy (DOE), the Environmental Protection Agency (EPA), FEMA, the Department of Commerce and other agencies, ensuring, for example, that research conducted in DOE's enhanced residential buildings program is quickly transferred into practice. The FY 2001 budget request for building efficiency efforts, such as PATH, Energy Star, and Building America, totals $275 million, a 42 percent increase over FY 2000 appropriations.

- ***Energy Efficient Appliances and Products.*** Various DOE and EPA programs aim to promote the dissemination of energy efficient appliances and products:

  -- DOE will accelerate its program to establish **energy efficiency standards** for commercial heating and cooling, water heaters, and electrical distribution transformers, and will begin efforts to harmonize international energy-efficiency standards and test methods to promote exports of efficient U.S. products.

  -- EPA and DOE's **Energy Star Products** program saves consumers money and reduces greenhouse gas emissions at the same time by promoting the use of energy efficient products – everything from computers to refrigerators to central air-conditioning units. New funding will support the launch of new Energy Star product lines and will promote the Energy Star labeling program in 6-10 export markets.

- ***Energy Efficient Commercial Buildings.*** DOE and EPA work in partnership with industry to research, develop, and deploy new technologies and practices to improve the energy performance of commercial buildings. Participants include the Empire State Building, the World Trade Center, and Chicago's Sears Tower. Buildings in the top 25 percent in energy efficiency qualify for EPA's **"Energy Star Buildings"** label.

- ***Energy Smart Schools/Energy Star Label for Schools.*** DOE and EPA have two programs that are working in coordination to improve energy efficiency in U.S. primary and secondary schools, bringing together public and private sector resources to cut schools' energy bills so that the savings can be reinvested in students and their education.

TRANSPORTATION

- ***Partnership for a New Generation of Vehicles.*** PNGV is a government-industry effort that aims to develop attractive, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. Since 1993, great strides have been made in producing lower-cost, light-weight materials, inexpensive fuel cells, and advanced internal combustion engines for use in hybrid vehicles. The program aims to produce a prototype mid-sized family car capable of 80 miles per gallon with a two-thirds reduction in carbon emissions by 2004. In January 2000, the auto-industry partners unveiled their PNGV "concept cars" at the Detroit Auto Show, which keeps the program on schedule for meeting its 2004 goal. The FY 2001 budget includes $255 million for PNGV-related work, an increase of $30 million over the amount appropriated for FY 2000.

- ***Light and Heavy Trucks.*** Similar government-industry efforts are aimed at developing cleaner, more efficient diesel engines for both light and heavy trucks.

  -- By 2003, DOE aims to develop **advanced diesel cycle engine technologies** for pickup trucks, vans, and sport utility vehicles which achieve at least a 35 percent fuel efficiency improvement relative to current gasoline-fueled trucks while meeting strict emission standards.

  -- By 2004, DOE, in coordination with EPA and the Department of Defense, aims to develop **engine and vehicle technologies for heavy trucks** that will increase the fuel economy to 10 mpg from the current average of 7 mpg.

INDUSTRY

- ***Industries of the Future.*** This DOE program works cooperatively with the nation's most energy-intensive industries – such as aluminum, glass, chemicals, forest products, mining, petroleum refining, and steel – developing technologies that increase energy and resource efficiency. Promising collaborative efforts include improvements in the process of making steel, pulp and paper, and other energy-intensive products that could dramatically increase efficiency, lower greenhouse gas emissions, and improve competitiveness.

- ***Industrial Combined Heat and Power (CHP) Systems.*** DOE is developing new industrial CHP systems to capture thermal heat would otherwise be wasted. These systems are expected to be 15 percent more energy efficient and 80 percent cleaner than conventional power systems and cut electricity costs by 10 percent. In addition, EPA and DOE are also working to eliminate barriers to the rapid dissemination of combined heat and power technology.

- ***Voluntary Industrial Partnerships.*** EPA will expand its industry partnership programs, such as **Climate Wise** and the **Voluntary Aluminum Industrial Partnership**, to

Other Climate-Related Investments

There are a number of additional programs for which funding is proposed in the FY 2000 budget that – while not part of the Climate Change Technology Initiative (CCTI) per se – contribute to improving energy efficiency and reducing greenhouse gas emissions. These programs include:

- ***Cleaner Coal and Natural Gas.*** The FY 2000 budget includes a total of $232 million (of which $56 million is part of CCTI) to support the Department of Energy's (DOE) aggressive R&D effort to develop next-generation technologies for the combustion and use of coal and natural gas. For example, research and development of integrated gasification combined cycle technology could lead to ultra-high efficiency coal plants with significantly lower greenhouse gas emissions.

- ***Low Income Weatherization and State Energy Grants.*** These DOE programs facilitate energy efficiency investments at the State and local level. The **Weatherization Assistance Program**, for example, delivers energy conservation services, such as insulation, to low-income Americans, reducing energy costs for consumers, improving health and safety, and reducing carbon emissions. The total FY 2001 budget request for these two programs is $191 million – a $22 million increase over FY 2000 appropriations.

- ***Agricultural & Forestry Conservation Programs.*** The Administration's 2001 Farm Safety Net Initiative proposes an increase of $1.3 billion in FY 2001 funding for Department of Agriculture conservation programs. Many of these same programs have the co-benefit of reducing carbon emissions resulting from agriculture and forestry and enhancing the ability of "sinks," such as forests and farmlands, to sequester or store carbon. This includes programs such as the **Conservation Reserve Program**, the **Environmental Quality Incentives Program**, and the **Farmland Protection Program**. In general, these programs assist farmers, ranchers, and other landowners in conserving and improving soil, water, and other natural resources associated with rural land.

U.S. Global Change Research Program

The United States Global Change Research Program (USGCRP) seeks to provide a sound scientific understanding of both the human and natural forces that influence the Earth's climate system. USGCRP science results provide useful information for environmental decision-making on issues such as climate change, ozone depletion, changes in ecosystems, and land use. This multi-agency effort is coordinated through the National Science and Technology Council.

For FY 2001, the President is requesting $1.74 billion for the USGCRP, an increase of $39 million above the amount enacted for FY 2000. $843 million is for scientific research and improvements to surface-based monitoring, (an increase of $79 million, or about 10 percent). $923 million is for NASA's development of Earth observing satellites to monitor climate change and other global changes (a decrease of $34 million, reflecting the phasing of funding for large development projects). Important USGCRP budget highlights include:

- ***Improved Climate Observations.*** The FY 2001 budget provides $26 million to enhance NOAA surface-based observations, including creation of a climate reference network to provide, for the first time, automated, simultaneous, and ideally located measurements of changing temperatures, precipitation, and soil moisture. Measurements of atmospheric trace gases, aerosols, ocean temperatures, and ocean currents will also be expanded.

- ***The Global Water Cycle.*** The FY 2001 budget provides $308 million (an increase of $35 million, or about 13 percent) for research on changes in the Earth's water cycle, which is one of the primary determinants of the Earth's climate. The water cycle is emerging as a top research priority because changes appear to occurring already. The launch of NASA's EOS Aqua spacecraft in December 2000 will support this research by provide new global measurements of humidity, cloud properties, precipitation, snow, and sea ice.

- ***Ecosystem Changes.*** The FY 2001 budget provides $224 million for research on the potential impacts of climate change and other stresses on forests, coastal areas, croplands, and other ecosystems (an increase of $19 million, or 9 percent). New studies will improve our understanding of the relationships among land cover, land use, climate, and weather, and help identify "thresholds" for significant changes in ecosystems.

- ***Carbon Cycle Initiative.*** The FY 2001 budget request continues strong support for the multi-agency carbon cycle science initiative begun in FY 2000, providing $227 million (an increase of $23 million or 11 percent). This request includes funds to study how carbon cycles between the atmosphere, the oceans, and land, and the role of farms, forests, and other natural or managed lands in capturing carbon. Such carbon "sinks" may help the United States and other nations offset greenhouse gas emissions. Key agencies include the Departments of Agriculture (USDA), Energy, Interior, NASA, the National Science Foundation, and the Smithsonian Institution. Included in the request is $13.5 million (an increase of over $12 million) to significantly expand USDA Natural Resources Conservation Service soil carbon inventory and analysis efforts.

President Clinton's FY 2001 Climate Change Budget

"The greatest environmental challenge of the new century is global warming . . . If we fail to reduce the emission of greenhouse gases, deadly heat waves and droughts will become more frequent, coastal areas will flood, and economies will be disrupted. That is going to happen, unless we act. Many people . . . still believe you cannot cut greenhouse gas emissions without slowing economic growth. In the Industrial Age that may well have been true. But in this digital economy, it is not true anymore. New technologies make it possible to cut harmful emissions and provide even more growth."

-- President Bill Clinton, State of the Union Address, January 27, 2000

Meeting the Challenge of Global Warming. Against a backdrop of growing scientific consensus that the Earth is warming – and that human activities are at least partly to blame – President Clinton's FY 2001 budget is proposing $2.4 billion (a 43 percent increase over FY 2000 enacted levels) in funding to combat global climate change. This includes a series of new initiatives, such as accelerated efforts to develop clean energy sources both at home and abroad and a new Clean Air Partnership Fund to boost state and local efforts to reduce greenhouse gases and air pollution, as well as a five-year package of tax incentives to spur clean energy technologies and increased investment for R&D in energy efficient technology and renewable energy. In addition, the President is proposing more than $1.7 billion for global change research, for a total package for FY 2001 of over $4 billion.

International Clean Energy Initiative. To help accelerate the development and deployment of clean energy technologies around the world, President Clinton is proposing $201 million (a more than 100 percent increase over FY 2000 enacted levels) for a multi-agency initiative to encourage open competitive markets; remove market barriers in developing countries to clean energy technologies; and to provide new incentives for clean energy technology innovation and export. The initiative will promote U.S. clean energy exports, create high-value jobs, and assist developing countries in fighting air pollution and climate change.

Bioenergy & Bio-based Products Initiative. The budget includes $289 million to accelerate the development of bio-based technologies, which convert crops, trees and other "biomass" into a vast array of fuels and products – an increase of $93 million over FY 2000 enacted levels. In addition to helping meet environmental challenges like global warming, this initiative will increase the viability of alternative energy sources, support farm incomes, and diversify and strengthen the rural economy.

Clean Air Partnership Fund. The President proposes $85 million for a new fund to provide grants to state and local governments for projects that reduce both greenhouse gases and pollutants like soot, smog, and air toxics.

Climate Change Technology Initiative (CCTI). The CCTI is a package of targeted tax incentives and investments aimed at increasing energy efficiency and spurring the broader use of renewable energy. The package will save consumers money and reduce greenhouse gas emissions at the same time. CCTI investments have risen substantially each of the past two years. The President's new budget proposes a still more accelerated effort.

> **$4.0 billion in Tax Incentives over 5 years.** The proposed package contains $4.0 billion over five years in tax cuts ($201 million for FY 2001) for consumers who purchase energy efficient products and for producers of energy from renewable sources. This year's CCTI tax package is $400 million greater than last year's proposed five-year package. Highlights include:

- <u>Tax credits for energy efficient homes</u>. Consumers can receive a $1000-2000 credit

- Tax credits for fuel-efficient cars. The package extends the current tax credit (of up to $4000) through 2006 for qualified electric and fuel cell vehicles and also includes a tax credit of $500-3000 for the purchase of a qualifying hybrid vehicle from 2003-2006.

- Tax credits for clean energy. The package extends the 1.5 cent per kilowatt hour tax credit for the production of electricity from wind and closed-loop biomass; provides credits for open-loop biomass facilities and coal-biomass cofiring; and provides credits for electricity produced from methane from certain landfills.

$1.4 billion for Energy Efficiency & Clean Energy. The proposed package contains over $1.4 billion in FY 2001 to research, develop, and deploy clean technologies for the four major carbon-emitting sectors of the economy -- buildings, transportation, industry, and electricity – a 30 percent increase over the amount appropriated in FY 2000. Highlights include:

- Partnership for a New Generation of Vehicles. PNGV is a government-industry effort to develop comfortable, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. The combined proposal for PNGV in the FY 2001 budget is $255 million, an increase of $30 million over FY 2000 enacted levels.

- Partnership for Advancing Technology in Housing. PATH is a government-industry partnership to improve the energy efficiency of new homes by more than 50 percent and to retrofit 15 million existing homes to make them 30 percent more energy efficient within a decade. The FY 2001 budget request for building efficiency efforts, such as PATH, Energy Star, and Building America, totals $275 million, a 42 percent increase over FY 2000 appropriations.

- Renewable Energy. The President proposes $410 million for the Department of Energy's solar and renewable energy programs, a 32 percent increase over the amount appropriated in FY 2000. The package includes expanded efforts in key renewable technologies, such as wind, bioenergy, photovoltaics, and geothermal energy.

Cleaner Fossil Fuels. The budget request contains $233 million for R&D to develop next-generation technologies for coal combustion with much higher energy efficiency and lower greenhouse gas emissions.

Weatherization & State Energy Grants. The budget request includes $191 million -- a $22 million increase over FY 2000 appropriations -- to deliver energy conservation services to low-income Americans and to assist state energy offices in addressing their energy priorities.

U.S. Global Change Research Program. The FY 2001 request includes over $1.7 billion for scientific research to improve our understanding of human and natural forces that influence the Earth's climate system and to assess the likely consequences of global warming.

toward the purchase of a new energy efficient home; a 20 percent tax credit for the purchase of selected energy efficient products for homes and buildings; and a $1000-2000 credit for installing a solar energy system.

Climate Change Technology Initiative: $4.0 Billion in Tax Incentives

The President is proposing a new $4.0 billion package in tax incentives over five years to help reduce greenhouse gas emissions by spurring the purchase of energy efficient products and the use of renewable energy (see Table 2).

Table 2. CCTI Tax Incentives ($ in Millions) — **Revenue Effect**

	FY 2001	**Total FY01-05**
Homes and Buildings		
Provide tax credit for energy efficient building equipment	-18	-201
Provide tax credit for new energy efficient homes	- 82	-633
Provide tax credit for solar energy systems	-9	-132
Vehicles		
Extend tax credit for electric and fuel cell vehicles and provide tax credits for qualified hybrid vehicles	0	-2078
Clean Energy		
Extend tax credit for electricity produced from wind and closed-loop biomass; provide credits for open-loop biomass facilities and coal-biomass cofiring; and provide credits for methane from certain landfills	-91	-976
Industry		
Provide 15-year recovery period for distributed power property	-1	-10
TOTAL**	**-201**	**-4030**

**Total may not add due to rounding.

HOMES AND BUILDINGS

- ***Tax credit to consumers who purchase new energy efficient homes.*** To encourage the purchase of new energy efficient homes, consumers would receive a tax credit of $1,000 for homes purchased from 2001-2003 that use at least 30 percent less energy than the standard under the 1998 International Energy Conservation Code (IECC) and a credit of $2,000 for homes purchased from 2001-2005 that use at least 50 percent less energy than the IECC standard.

- ***Tax credit for energy efficient equipment in new and existing homes or buildings.*** This credit will encourage the purchase of electric heat pump water heaters, natural gas heat pumps and fuel cells. The credit would apply to both residential and commercial equipment. The credit would be 20 percent of the cost of the investment, subject to a cap, for equipment purchased from 2001-2004.

- ***Tax credit for solar energy systems.*** A 15 percent tax credit will encourage the purchase by consumers and businesses of solar energy systems. The maximum credit would be $2,000 for rooftop photovoltaic systems placed in service from 2001-2007 and $1,000 for solar water heating systems placed in service from 2001-2005.

VEHICLES

- ***Tax credits for electric, fuel cell, and qualified hybrid vehicles.*** Cars and light trucks (including minivans, sport utilities, and pickups) currently account for 20 percent of greenhouse gas emissions. Tax credits for electric, fuel cell, and hybrid vehicles will help to move advanced technologies from the laboratory to the highway. These technologies can significantly reduce emissions of carbon dioxide, the most prevalent greenhouse gas.

  --Extend the current tax credit for electric vehicles and fuel cell vehicles. Under current law, a 10 percent credit, up to $4,000, is provided for the cost of qualified electric vehicles and fuel cell vehicles. The credit begins to phase down in 2002 and phases out in 2005. The President's proposal would extend the tax credit at its $4,000 maximum level through 2006.

  --Tax credits for hybrid vehicles. The credit -- available for all qualifying vehicles, including cars, minivans, sport utility vehicles, and pickup trucks -- would range from $500 to $3,000 for purchases of a qualified hybrid vehicle from 2003 through 2006, depending upon the vehicle's design performance.

CLEAN ENERGY

- ***Tax credit for electricity produced from wind.*** Current law encourages the production of electricity from wind, which emits no greenhouse gases, through a tax credit of 1.5 cents per kilowatt hour (adjusted for inflation after 1992). The current tax credit covers facilities placed in service before January 1, 2002. The President proposes a 2.5-year extension of this tax credit.

- ***Tax credits for electricity produced from biomass.*** Biomass refers to trees, crops and agricultural wastes used to produce power, fuels or chemicals. This package of credits would:

  -- Extend current "closed-loop" biomass credit. This proposal extends for 2.5 years the current 1.5 cent per kilowatt hour tax credit (adjusted for inflation after 1992), which covers facilities placed in service before January 1, 2002.

  -- Provide credits for "open loop" biomass facilities. This proposal expands the definition of biomass eligible for the 1.5 cent tax credit to include certain forest-related resources and agricultural and other sources for facilities placed in service from 2001 through 2005, and provides a 1.0 cent credit for electricity produced from 2001 through 2003 from facilities placed in service prior to January 1, 2001.

-- **Provide a credit for cofiring biomass and coal.** This proposal adds a 0.5 cent per kilowatt hour tax credit for electricity produced by cofiring biomass in coal plants from 2001 through 2005.

-- **Provide credit for methane from landfills**. This proposal adds a 1.5 cent per kilowatt hour credit for electricity produced from landfills not subject to EPA's 1996 New Source Performance Standards/Emissions Guidelines (NSPS/EG) and 1.0 cent per kilowatt hour for landfills subject to NSPS/EG. Qualified facilities would be facilities placed in service after December 31, 2000 and before January 1, 2006.

INDUSTRY

- ***15-year recovery period for distributed power property.*** The development of distributed power technologies has made it possible to generate electricity locally at dispersed industrial, commercial, and residential locations. Such technologies can be more energy efficient and generate fewer greenhouse gases than conventional generation methods. This proposal would simplify and rationalize the current depreciation system by assigning a single 15-year recovery period to distributed power property.

International Clean Energy Initiative

To accelerate the development and deployment of clean energy technologies around the world, President Clinton is proposing the Clean Energy for the 21st Century: International Initiative – a $200 million multi-agency effort (a more than 100 percent increase over FY 2000 enacted levels) to encourage open competitive markets and remove market barriers to clean energy technologies in developing and transition countries and to provide new incentives for clean energy technology innovation and export. This initiative will promote U.S. exports and create high-value jobs, and will assist countries power their economic development while fighting air pollution and climate change.

Window of Opportunity for America and the World. Developing country energy use will overtake that of industrial countries by 2020. These energy technology markets are projected to total $4 to $5 trillion over the next 20 years and $15 to $25 trillion over the next 50 years. Developing country energy use is expected to account for three-fourths of the increase in global energy use between now and 2050.

Advanced, low-polluting energy technologies can provide these energy services efficiently, but existing markets often do not value these benefits. In addition, environmentally superior options often carry higher up-front costs, may be unfamiliar, or are perceived as more risky by decision-makers in developing countries. The initiative builds on a recent set of recommendations by the President's Committee of Advisors on Science and Technology (PCAST) and is directed at leveling the playing field between cleaner U.S. energy technologies and services and polluting alternatives.

Real Benefits At Home and Abroad. The initiative will help lay the technical and policy foundation that will allow developing and transition countries to build a clean energy future, leapfrogging past the polluting energy technologies used by the industrial countries, while building competitive markets open to U.S. firms. The goals of this initiative include:

- Doubling clean energy technology exports by 2005, creating as much as $5 billion in new export revenues for U.S. companies and as many as 100,000 new U.S. jobs.
- Cutting energy use in targeted country buildings and appliances in half through advanced building design tools and building equipment codes and standards.
- Developing integrated renewable energy technologies that have the potential to power the full range of energy services for the 2 billion people in developing countries that do not now have electricity.
- Sharply reducing sulfur, particulate, and greenhouse gas emissions by developing advanced coal-fired power plants and low-cost hydrogen fuels.
- Maximizing use of combined heat & power systems through technical and policy assistance.

- Reducing transition and developing country methane emissions from pipelines and other fossil sources by an amount equal to 100 million metric tons of carbon per year by 2005.

- Providing technical and policy support to encourage the development of natural gas grids.

- Reducing energy use in the industrial sector through the introduction of best practice methods, including advanced sensors and controls, and energy efficient motor drive systems.

- Conducting research in nuclear energy to address cost, waste, safety, and proliferation concerns.

Initiative Structure. This initiative will streamline current bureaucratic procedures to better assist U.S. firms wishing to invest in clean energy projects in developing and transition countries. In so doing, it will encourage public-private partnerships with foreign counterparts to demonstrate clean energy technologies, drive down their cost, and facilitate private sector financing for their large-scale deployment. It will also encourage open, competitive markets while protecting public interests. The initiative will employ a range of proven policy tools, including U.S. technical and policy assistance to developing countries through personnel exchanges, conducting collaborative R&D with key foreign research groups, developing integrated renewable energy, energy efficiency, and advanced fossil energy technologies and pilot projects, and providing a range of trade supports to expand clean energy exports.

The initiative's requested $103 million increase for these activities includes an additional $49 million for activities at the Department of Energy; $30 million for the U.S. Agency for International Development; $15 million for the Export-Import Bank; $5 million for the Trade and Development Agency; and, $4 million for the Department of Commerce.

President Clinton's FY 2000 Climate Change Budget

> *"Our most fateful new challenge is the threat of global warming...Tonight I propose a new clean air fund to help communities reduce greenhouse and other pollution, and tax incentives and investments to spur clean energy technology."*
>
> President Bill Clinton, State of the Union address, January 19, 1999

Meeting the challenge of global warming. In his FY 2000 budget, the President is proposing a 34 percent increase for R&D in energy efficient technology and renewable energy; a new Clean Air Partnership Fund to boost state and local efforts to reduce greenhouse gases and air pollution; a five-year package of tax incentives to spur clean energy technologies; substantial new funding to focus on the ways farms and forests can reduce and offset greenhouse gas emissions; and \$1.8 billion for global change research -- a total package for FY 2000 of over \$4 billion.

Clean Air Partnership Fund. The President proposes \$200 million for a new fund to provide grants to state and local governments for projects that reduce both greenhouse gases and pollutants like soot, smog, and air toxics.

Climate Change Technology Initiative (CCTI). The CCTI is a package of targeted tax incentives and investments aimed at increasing energy efficiency and spurring the broader use of renewable energy. The package will save consumers money and reduce greenhouse gas emissions at the same time. FY 1999 appropriations represented a 25 percent increase over the prior year. The President's new budget proposes a still more accelerated effort.

\$3.6 billion in tax incentives over five years. The proposed package contains \$3.6 billion over five years in tax cuts (\$383 million for FY 2000) for consumers who purchase energy efficient products and for producers of energy from renewable sources. Highlights include:

- <u>Tax credits for energy efficient homes</u>. Consumers can receive a \$1000-2000 credit toward the purchase of a new energy efficient home; a 10-20 percent tax credit for the purchase of selected energy efficient products for their homes and buildings; and a \$1000-2000 credit for installing a rooftop solar system.

- <u>Tax credits for fuel-efficient cars</u>. The package includes tax credits ranging from \$1000-4000 for the purchase of a qualifying electric, fuel cell or hybrid vehicle.

- <u>Tax credits for renewable energy</u>. The package extends the 1.5 cent per kilowatt hour tax credit for the production of electricity from wind and biomass; expands the biomass credit to cover additional sources of biomass; and adds a 1.0 cent per kilowatt hour tax credit for cofiring coal and biomass in power plants.

\$1.4 billion for Energy Efficiency & Renewables. The proposed package contains nearly \$1.4 billion in FY 2000 to research, develop, and deploy clean technologies for the four major carbon-emitting sectors of the economy -- buildings, transportation, industry, and electricity -- a 34 percent increase over the amount appropriated in FY 1999. Highlights include:

- <u>Partnership for a New Generation of Vehicles</u>. PNGV is a government-industry effort to develop comfortable, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. The combined proposal for PNGV in the FY 2000 budget is \$264 million, an increase from the \$240 million appropriated in FY 1999.

- Partnership for Advancing Technology in Housing. PATH is a government-industry partnership to improve the energy efficiency of new homes by more than 50 percent and to retrofit 15 million existing homes to make them 30 percent more energy efficient within a decade. The FY 2000 budget request for building efficiency efforts, such as PATH, Energy Star, and Building America, totals $273 million, a 59 percent increase over FY 1999 appropriations.

- Renewable energy. The President proposes $399 million for the Department of Energy's (DOE) solar and renewable energy programs, a 19 percent increase over the amount appropriated in FY 1999. The package includes expanded efforts in key renewable technologies, such as wind, bioenergy, photovoltaics, and geothermal energy.

Forests and Farms. The FY 2000 proposal includes $105 million for the Department of Agriculture's (USDA) climate change budget, an increase of $50 million over the amount appropriated in FY 1999 and $40 million over the Administration's FY 1999 request. The new proposal includes funding for a new, multi-agency Carbon Cycle Initiative to better understand how carbon is absorbed by agricultural soils and forests; a soil carbon inventory; pilot projects to demonstrate how improved farming practices can help store carbon; and programs to reduce emissions through means such as the conversion of waste to energy. In addition, DOE, in conjunction with USDA, will expand efforts aimed at broadening the use of biomass to produce power, fuels, and chemicals.

Cleaner Coal. The budget request contains $122 million for R&D to develop next-generation technologies for coal combustion with much higher energy efficiency and lower greenhouse gas emissions.

Weatherization & State Energy Grants. The budget request includes $191 million -- a $25 million increase over FY 1999 appropriations -- to deliver energy conservation services to low-income Americans and to assist state energy offices in addressing their energy priorities.

U.S. Global Change Research Program. The FY 2000 request includes $1.8 billion for scientific research to improve our understanding of human and natural forces that influence the Earth's climate system and to assess the likely consequences of global warming.

President Clinton's FY 2000 Climate Change Budget

The President's climate change package for FY 2000 totals over $4.1 billion -- an increase of more than $1 billion (34 percent) from the amount enacted for FY 1999. It is comprised of a new Clean Air Partnership Fund to boost state and local efforts to reduce both greenhouse gases and ground-level air pollutants; the Climate Change Technology Initiative, which mixes tax incentives and direct spending to spur the research, development, and deployment of energy efficient technology and renewable energy; other climate-related investments, such as R&D of highly efficient technologies for the combustion and use of coal and natural gas, weatherization, and state energy grants; and the United States Global Change Research Program, to enhance our understanding of the human and natural forces that influence the Earth's climate system.

Table 1. Climate-Change-Related Domestic Programs ($ in Millions)

	FY 1999 Enacted	FY 2000 Request	Change
Clean Air Partnership Fund	0	200	+200
Climate Change Technology Initiative--tax incentives	--	383*	+383
Climate Change Technology Initiative--spending	1,021	1,368	+347
Other Climate-Related Investments (cleaner coal & natural gas; weatherization; state energy grants)	387	400	+13
Global Change Research Program	1,681	1,786	+105
TOTAL	**3,090**	**4,137**	**+1,048**

*First year of a proposed five year, $3.6 billion package.

Clean Air Partnership Fund

To help protect public health and ease the threat of global warming, President Clinton is proposing $200 million for the creation of a new Clean Air Partnership Fund. The Fund will provide grants to states, localities, and tribes to support state, local, tribal, and private efforts that achieve reductions in both greenhouse gas emissions and ground-level air pollutants. The Fund will be administered by the Environmental Protection Agency (EPA) under existing authority.

- ***Integrated Pollution Control.*** The Fund will stimulate integrated, cost-effective pollution control strategies. It directs new resources to state, local, and tribal governments to finance projects and programs that achieve accelerated reductions in both air pollutants, such as soot, smog, and air toxics, and in greenhouse gases.

- ***A Quicker Path to Cleaner Air.*** By providing new resources for projects that accelerate pollution reductions, the Fund will enable communities to achieve multi-pollutant clean air goals sooner and reduce greenhouse gas emissions at the same time.

- ***Technological Innovation.*** The Fund will help spur both public and private sector innovations in next-generation pollution control technology.

- ***A Magnet for Local Investment & Innovation.*** The Fund will encourage public-private partnerships to demonstrate ways to create a cleaner environment at the local level. The Fund can be used to support local revolving funds, low-interest loan programs, matching grants, and other mechanisms that will leverage the original Federal investment, greatly increasing its impact.

- ***"Win-Win" Clean Air Projects.*** The Fund will support a wide range of practical projects that will mean cleaner air, reduced greenhouse gas emissions, and real savings for taxpayers and consumers. These could include projects such as building combined heat and power facilities that put waste heat to work, reducing emissions of both sulfur dioxide and carbon dioxide; retrofitting municipal buildings to make them more energy efficient, reducing pollution resulting from electricity generation; and upgrading municipal vehicle fleets to make them more fuel efficient.

Climate Change Technology Initiative: $3.6 Billion in Tax Incentives

The President is proposing a new $3.6 billion package in tax incentives over five years to help reduce greenhouse gas emissions by spurring the purchase of energy efficient products and the use of renewable energy (see Table 2).

Table 2. CCTI Tax Incentives ($ in Billions)

	Revenue Effect	
	FY 2000	**Total FY00-04**
Homes and Buildings		
Provide tax credit for energy efficient building equipment	-0.2	-1.5
Provide tax credit for new energy efficient homes	-0.1	-0.4
Provide tax credit for rooftop solar systems	--*	-0.1
Vehicles		
Extend tax credit for electric or fuel cell vehicles and provide tax credits for highly fuel efficient hybrid vehicles	0	-0.9
Renewable Energy		
Extend tax credit for electricity produced from wind and biomass; expand eligible biomass sources; and include coal-biomass cofiring	--*	-0.3
Industry		
Provide tax credit for combined heat and power systems	-0.1	-0.3
TOTAL**	**-0.4**	**-3.6**

*Less than $50 million.
**Total may not add due to rounding.

HOMES AND BUILDINGS

- ***Tax credit to consumers who purchase new energy efficient homes.*** To encourage the purchase of new energy efficient homes, consumers would receive a tax credit of $1,000 for homes purchased from 2000-2001 that are at least 30 percent more energy efficient than the standard under the 1998 International Energy Conservation Code (IECC); a credit of $1,500 for homes purchased from 2000-2002 that are at least 40 percent more efficient than the IECC standard; and a credit of $2,000 for homes purchased from 2000-2004 that are at least 50 percent more efficient than the IECC standard.

- ***Tax credit for energy efficient equipment in new and existing homes or buildings.*** This credit will encourage the purchase of electric heat pump and natural gas water heaters, electric and natural gas heat pumps, advanced central air conditioners, and fuel cells. The credit would apply to both residential and commercial equipment. For electric heat pump water heaters, natural gas heat pumps, and fuel cells, the credit would be 20 percent of the cost of the investment, subject to a cap, for equipment purchased from 2000-2003. For all other equipment, the credit would be 10 percent of the cost of the investment, subject to a cap, at one level of efficiency (2000-2001) and 20 percent, subject to a cap, at a higher level of efficiency (2000-2003).

- ***Tax credit for rooftop solar systems.*** A 15 percent tax credit will encourage the purchase by consumers and businesses of rooftop solar systems. The maximum credit would be $2,000 for rooftop photovoltaic systems placed in service from 2000-2006 and $1,000 for solar water heating systems placed in service from 2000-2004.

VEHICLES

- ***Tax credits for highly efficient cars and light trucks.*** Cars and light trucks (including minivans, sport utilities, and pickups) currently account for 20 percent of greenhouse gas emissions. Tax credits for electric, fuel cell, and hybrid vehicles will help to move these highly efficient technologies from the laboratory to the highway. These technologies can significantly reduce emissions of carbon dioxide, the most prevalent greenhouse gas.

    - **Extend the current tax credit for electric vehicles and fuel cell vehicles.** Under current law, a 10 percent credit, up to $4,000, is provided for the cost of qualified electric vehicles and fuel cell vehicles. The credit begins to phase down in 2002 and phases out in 2005. The President's proposal would extend the tax credit at its $4,000 maximum level through 2006.

- **Tax credits for hybrid vehicles.** The credit -- available for all qualifying vehicles, including cars, minivans, sport utility vehicles, and pickup trucks -- would be:

  -- $1,000 for each vehicle that is one-third more fuel efficient than a comparable vehicle in its class -- available from 2003-2004;

  -- $2,000 for each vehicle that is two-thirds more fuel efficient than a comparable vehicle in its class -- available from 2003-2006;

  -- $3,000 for each vehicle that is twice as fuel efficient as a comparable vehicle in its class -- available from 2004-2006; and,

  -- $4,000 for each vehicle that is three times as fuel efficient as a comparable vehicle in its class -- available from 2004-2006.

RENEWABLE ENERGY

- ***Tax credit for electricity produced from wind.*** Current law encourages the production of electricity from wind, which emits no greenhouse gases, through a tax credit of 1.5 cents per kilowatt hour (adjusted for inflation after 1992). The current tax credit covers facilities placed in service before July 1, 1999. The President proposes a 5-year extension of this tax credit.

- ***Tax credits for electricity produced from biomass.*** Biomass refers to trees, crops and agricultural wastes used to produce power, fuels or chemicals. This package of credits would:

  -- Extend current biomass credit. This proposal extends for five years the current 1.5 cent per kilowatt hour tax credit (adjusted for inflation after 1992), which covers facilities placed in service before July 1, 1999.

  -- Expand definition of eligible biomass. This proposal expands the definition of biomass eligible for the 1.5 cent tax credit to include certain forest-related resources and agricultural and other sources.

  -- Include cofiring biomass and coal. This proposal adds a 1.0 cent per kilowatt hour tax credit for electricity produced by cofiring biomass in coal plants.

INDUSTRY

- ***Tax credit for combined heat and power (CHP) systems.*** CHP systems make effective use of thermal energy that is otherwise wasted in producing electricity by more conventional methods. To encourage and accelerate investment in CHP equipment, this proposal provides an 8 percent tax credit for investments in large CHP systems that have a total energy efficiency exceeding 70 percent and in smaller systems that have a total energy efficiency exceeding 60 percent. The credit would apply to property placed in service from 2000-2002.

Climate Change Technology Initiative:
$1.4 Billion for Energy Efficiency & Renewables

The President's FY 2000 budget proposes nearly $1.4 billion for the research, development, and deployment of renewable energy technologies and energy efficient products that will help reduce U.S. greenhouse gas emissions. This represents a $347 million increase (34 percent) over FY 1999 spending (see Table 3). The President's proposed investment package covers the four major carbon-emitting sectors of the economy -- buildings, transportation, industry, and electricity -- as well as carbon sequestration (see Table 4). The following sections highlight selected programs in each of these areas of effort. The full agency programs extend well beyond what is described here.

Table 3. CCTI Funding by Agency ($ in Millions)

	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request	Change from 1999
Energy	729	902	1,124	+222
EPA	90	109	216	+107
Housing & Urban Development	0	10	10	0
Agriculture	0	0	16	+16
Commerce	0	0	2	+2
TOTAL*	**819**	**1,021**	**1,368**	**+347**

*Totals may not add due to rounding

Table 4. CCTI Funding by Area of Activity ($ in Millions)

	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request	Change from 1999
Buildings	140	172	273	+101
Transportation	245	291	377	+86
Industry	157	188	239	+51
Electricity	239	310	379	+69
Carbon Sequestration	0	14	39	+25
Management, Planning & Analysis	37	46	60	+14
TOTAL*	**819**	**1,021**	**1,368**	**+347**

* Totals may not add due to rounding.

BUILDINGS

- ***Partnership for Advancing Technology in Housing (PATH).*** PATH is a partnership between the Federal government and building industry to develop and deploy housing technologies to make new homes 50 percent more energy efficient and to make at least 15 million existing homes 30 percent more energy efficient within a decade.

- ***Energy Efficient Appliances and Products.*** Various DOE and EPA programs aim to promote the dissemination of energy efficient appliances and products:

  -- DOE will accelerate its program to establish **energy efficiency standards for lighting and appliances**.

  -- EPA and DOE's **Energy Star Products** program saves consumers money and reduces greenhouse gas emissions at the same time by promoting the use of energy efficient products -- everything from computers to refrigerators to central air-conditioning units. New funding will support the launch of new Energy Star product lines.

- ***Energy Efficient Commercial Buildings.*** DOE and EPA work in partnership with industry to research, develop, and deploy new technologies and practices to improve the energy performance of commercial buildings. Buildings in the top 25 percent in energy efficiency qualify for EPA's **"Energy Star Buildings"** label. Participants include the Empire State Building, the World Trade Center, and Chicago's Sears Tower.

- ***Energy Smart Schools.*** Announced in October 1998, this initiative cuts across several DOE programs and brings together public and private sector resources to cut schools' energy bills so that the savings can be reinvested in students and their education.

TRANSPORTATION

- ***Partnership for a New Generation of Vehicles (PNGV).*** PNGV is a government-industry effort that aims to develop attractive, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. Since 1993, great strides have been made in producing lower-cost, light-weight materials, inexpensive fuel cells, and advanced internal combustion engines for use in hybrid vehicles. The program aims to produce a prototype mid-sized family car capable of 80 miles per gallon (mpg) with a two-thirds reduction in carbon emissions by 2004. The FY 2000 budget includes $264 million for PNGV-related work, an increase of $24 million over the amount appropriated for FY 1999.

- ***Light and Heavy Trucks.*** Similar government-industry efforts are aimed at developing cleaner, more efficient diesel engines for both light and heavy trucks.

  -- By 2002, DOE aims to develop **advanced diesel cycle engine technologies** for pickup trucks, vans, and sport utility vehicles which achieve at least a 35 percent fuel efficiency improvement relative to current gasoline-fueled trucks while meeting strict emission standards.

  -- By 2004, DOE, in coordination with EPA and the Department of Defense, aims to develop **engine and vehicle technologies for heavy trucks** that will increase the fuel economy to 12 mpg from the current average of 5.3 mpg.

- ***Biofuels.*** Working with the Department of Agriculture (USDA), DOE will continue its work in the biochemistry of converting wood chips, grasses, agricultural wastes, and other products into ethanol and other potentially useful fuels.

INDUSTRY

- ***Industries of the Future.*** This DOE program works cooperatively with the nation's most energy-intensive industries -- such as aluminum, glass, chemicals, forest products, mining, petroleum refining, and steel -- on developing technologies that increase energy and resource efficiency. Promising collaborative efforts include improvements in the process of making steel, pulp and paper, and other energy-intensive products that could dramatically increase efficiency, lower greenhouse gas emissions, and improve competitiveness.

- ***Industrial Combined Heat and Power (CHP) Systems.*** DOE is developing new industrial CHP systems to capture thermal heat would otherwise be wasted. These systems are expected to be 15 percent more energy efficient and 80 percent cleaner than conventional power systems and cut electricity costs by 10 percent. In addition, EPA and DOE are also working to eliminate barriers to the rapid dissemination of combined heat and power technology.

- ***Voluntary Industrial Partnerships.*** EPA will expand its industry partnership programs, such as **Climate Wise** and the **Voluntary Aluminum Industrial Partnership**, to encourage businesses to take advantage of cost-effective emissions reductions opportunities -- including emissions of the most potent greenhouse gases, such as methane, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulfur hexaflouride (SF6).

- ***Agriculture and Forestry.*** USDA will undertake R&D and support demonstration projects aimed at both lowering greenhouse gas emissions from agriculture and forestry and reducing their vulnerability to climate change.

  --The **Natural Resources Conservation Service** will invest $3 million in projects to demonstrate and test various means of reducing greenhouse gas emissions in agriculture, such as compost-based waste-handling facilities, rotational grazing systems, and improved feed and forage systems.

  --The **Agricultural Research Service** will devote $7 million towards climate change related activities, including the development of new technology and expertise for reducing agriculture's vulnerability to a changing climate. Field experiments will seek to measure various potential effects of climate change, such as varying amounts and patterns of rainfall on forage production.

The FY 2000 budget also includes important USDA funding for developing advanced biomass energy technologies; R&D and demonstration projects for carbon sequestration; research to study the role of farms, forests, and other natural or managed lands in capturing and storing carbon; and a comprehensive U.S. soil carbon inventory (see pp. 10-12 below).

ELECTRICITY

- ***Photovoltaic Energy Systems.*** Over the past 20 years, Federal R&D has resulted in a 90 percent cost reduction in solar photovoltaics. DOE will accelerate R&D of the next generation photovoltaic cells; increase manufacturing R&D; increase research in buildings-integrated applications; and fund efforts to develop new, unconventional technologies.

  -- **Million Solar Roofs.** In June, 1997, the President announced an initiative to encourage the installation of one million solar systems by 2010, which would reduce carbon emissions equivalent to the annual emissions from 850,000 cars. DOE has received commitments for over half a million solar rooftop installations.

- ***Biomass.*** Biomass represents a tremendous renewable resource whose use can help strengthen our energy security, protect the environment, and enhance our rural economy.

  -- **Biomass Power.** DOE is testing and demonstrating biomass co-firing with coal; developing advanced technologies for biomass gasification using paper industry by-products; and developing and testing high-yield, low-cost biomass feedstocks.

-- **Advanced Biomass Technologies.** This year DOE, USDA, and other Federal agencies and private partners will launch a national partnership to develop advanced integrated biomass technologies. These technologies will enable the production of power, transport fuels, and high-value chemicals from biomass feedstocks.

- ***Wind Power.*** DOE will continue developing a next-generation wind turbine able to produce power at 2.5 cents per kilowatt-hour in good wind regions, accelerate R&D on critical components, and accelerate testing and field validation.

- ***Hydrogen.*** DOE will accelerate research on low-cost hydrogen production and storage, prerequisites to the widespread use of hydrogen as a fuel.

- ***High Temperature Superconductivity.*** DOE supports industry-led projects to capitalize on recent breakthroughs in superconducting wire technology, aimed at developing devices such as advanced motors, power cables, and transformers. These technologies would allow more electricity to reach the consumer without an increase in fossil fuel input.

CARBON SEQUESTRATION

- ***R&D for Sequestration.*** Research initiatives are being funded to find ways to sequester (store) carbon. Examples include:

  -- **Enhancing Forest and Farmland Sinks.** The **Forest Service**, in conjunction with other USDA agencies, will spend $6 million for R&D and demonstration projects for optimizing forest, farmland, and rangeland carbon sinks. The focus of such projects will include storage of carbon in forest soils and increased durability and use of wood products to sequester carbon.

  -- **Enhancing natural geological and oceanic processes.** DOE will support research into the feasibility of capturing and storing carbon dioxide in underground geological structures and in the deep ocean.

Other Climate-Related Investments

There are a number of additional programs for which funding is proposed in the FY 2000 budget that -- while not part of the Climate Change Technology Initiative per se -- contribute to improving energy efficiency and reducing greenhouse gas emissions. These programs include:

- ***Cleaner Coal and Natural Gas.*** The FY 2000 budget includes $209 million to support the Department of Energy's (DOE) aggressive R&D effort to develop next-generation technologies for the combustion and use of coal and natural gas. For example, research and development of two new coal combustion technologies -- integrated gasification combined cycle and pressurized fluidized bed combustion -- could lead to ultra-high efficiency coal plants with dramatically lower greenhouse gas emissions.

- ***Low Income Weatherization and State Energy Grants.*** These DOE programs facilitate energy efficiency investments at the State and local level. The **Weatherization Assistance Program**, for example, delivers energy conservation services, such as insulation, to low-income Americans, reducing energy costs for consumers, improving health and safety, and reducing carbon emissions. The total FY 2000 budget request for these two programs is $191 million -- a $25 million increase over FY 1999 appropriations.

- ***Agricultural & Forestry Conservation Programs.*** Many Department of Agriculture conservation programs have the co-benefit of reducing carbon emissions resulting from agriculture and forestry and enhancing the ability of "sinks," such as forests and farmlands, to sequester or store carbon. This includes programs such as the **Conservation Reserve Program**, the **Environmental Quality Incentives Program**, and the **Farmland Protection Program**. In general, these programs assist farmers, ranchers, and other landowners in conserving and improving soil, water, and other natural resources associated with rural land.

U.S. Global Change Research Program

The United States Global Change Research Program (USGCRP) seeks to provide a sound scientific understanding of both the human and natural forces that influence the Earth's climate system. The information produced by USGCRP's scientists is used by national and international policy makers to make informed decisions on global change issues. This multi-agency scientific research program coordinated through the National Science and Technology Council.

For FY 2000, the President is requesting nearly $1.8 billion for the USGCRP, an increase of $105 million, or 6 percent, above the amount enacted for FY 1999. Of the FY 2000 budget request, $828 million is for scientific research (up $84 million) and $958 million is for NASA's development of climate monitoring satellites and ground based observation systems. Other important USGCRP budget highlights include:

- ***Carbon Cycle Initiative.*** The FY 2000 budget request establishes a new multi-agency initiative to improve our understanding of how carbon cycles between the atmosphere, the oceans, and land. Included in this request are funds to study the role of farms, forests, and other natural or managed lands in capturing carbon. Such carbon "sinks" may provide the U.S. and other nations with new tools for offsetting greenhouse gas emissions. The initiative includes $10 million in new funding for the Department of Agriculture (USDA) and $5 million for the Department of Energy.

- ***Soil Carbon Inventory.*** The FY 2000 budget request includes $14 million (an increase of $12 million from FY 1999 appropriations) to significantly expand efforts to conduct a comprehensive scientific inventory of carbon stored in U.S. soils and to develop methods to predict how soil carbon levels would be affected by different practices and policies. The inventory will be conducted by USDA's Natural Resources Conservation Service.

- ***3-Dimensional Mapping of Forests.*** The FY 2000 budget provides funding to launch NASA's Vegetation Canopy Lidar, which, for the first time, will give scientists a three dimensional view of the Earth's forests to help determine the contribution of forests in sequestering atmospheric carbon.

- ***Consequences of Climate Change.*** The FY 2000 budget provides funding to complete a report on the first national assessment of the potential consequences of climate change on the United States. The report will identify potential impacts on key economic sectors and geographic regions, mitigation and adaptation strategies, and provide technical information for policy makers.

- ***Regional Variability.*** The FY 2000 budget request includes funding to help scientists examine climate change and variability on a regional scale. Supported in part by the Administration's new Information Technology Initiative, the funding will help improve U.S. computer capabilities to run the complex models required to understand the effects of climate change and variability at the regional level.

Agriculture and The President's FY 2000 Climate Change Budget

Farmland, rangeland, and forests can play a critical role in meeting the challenge of global warming through carbon sequestration and renewable bioenergy. In his FY 2000 budget, the President is proposing $251 million in funding for sequestration and bioenergy research, development, and deployment. This includes $105 million for the Department of Agriculture (USDA), a $50 million increase over the amount appropriated for FY 1999, and $146 million for the Department of Energy (DOE), a $59 million increase over FY 1999 appropriated funds. Highlights include:

SEQUESTRATION

Carbon sequestration refers to the storage of carbon from the atmosphere by soils, trees, crops, and other plants.

- ***Demonstration Projects and New R&D.*** The Forest Service, the Agriculture Research Service and the Natural Resources Conservation Service will launch new R&D and demonstration projects to optimize farmland, rangeland, and forest carbon sinks.

- ***Carbon Cycle Initiative.*** The FY 2000 budget request establishes a new multi-agency initiative to improve our understanding of how carbon cycles between the atmosphere, the oceans, and land. Included in this request are funds to study the role of farms, forests, and other natural or managed lands in capturing carbon. Such carbon "sinks" may provide the U.S. and other nations with new tools for offsetting greenhouse gas emissions. The initiative includes $10 million in new funding for USDA and $5 million for DOE.

- ***Soil Carbon Inventory.*** The FY 2000 budget request includes $14 million to significantly expand efforts to conduct a comprehensive scientific inventory of carbon stored in U.S. soils and to develop methods to predict how soil carbon levels would be affected by different practices and policies.

BIOENERGY

Biomass refers to trees, crops and agricultural wastes used to produce power, fuels or chemicals. It represents a tremendous renewable resource whose use can help strengthen our energy security, protect the environment, and enhance our rural economy.

- ***Biomass Power and Fuels.*** DOE and USDA will continue developing, testing, and demonstrating high-yield, low-cost biomass feedstocks; testing and demonstrating biomass cofiring with coal; and seeking to produce alternative fuels, such as ethanol, from biomass.

- ***Advanced Biomass Technologies.*** This year, DOE, USDA and other Federal agencies and private partners will launch a national partnership to develop advanced integrated biomass technologies.

- ***Biomass Tax Credit.*** The President's tax package proposes to extend for 5 years the current 1.5 cent per kilowatt hour tax credit for electricity produced from biomass. The proposal also expands the types of biomass eligible for the credit to include certain forest-related, agricultural and other resources. Finally, the package includes a 1.0 cent per kilowatt hour tax credit for electricity produced by cofiring biomass in coal plants.

SR/OIAF-????

Analysis of The Climate Change Technology Initiative

DRAFT -- 4/2/99

Energy Information Administration
Office of Integrated Analysis and Forecasting
U.S. Department of Energy
Washington, DC 20585

Contacts

This report was prepared by the staff of the Office of Integrated Analysis and Forecasting of the Energy Information Administration. General questions concerning the report can be directed to Mary J. Hutzler (202/586-2222, mhutzler@eia.doe.gov), Director of the Office of Integrated Analysis and Forecasting; Susan H. Holte (202/586-4838, sholte@eia.doe.gov), Director of the Demand and Integration Division; James M. Kendell (202/586-9646, jkendell@eia.doe.gov), Director of the Oil and Gas Division; Scott B. Sitzer (202/586-2308, ssitzer@eia.doe.gov), Director of the Coal and Electric Power Division; and Andy S. Kydes (202/586-2222, akydes@eia.doe.gov), Senior Modeling Analyst. Specific questions about the report may be directed to the following analysts:

Residential	John H. Cymbalsky	202/586-4815	jcymbals@eia.doe.gov
Commercial	Erin E. Boedecker	202/586-4791	eboedeck@eia.doe.gov
Industrial	T. Crawford Honeycutt	202/586-1420	choneycu@eia.doe.gov
Transportation	David M. Chien	202/586-3994	dchien@eia.doe.gov
Electricity	J. Alan Beamon	202/586-2025	jbeamon@eia.doe.gov
Renewables	Thomas W. Petersik	202/586-6582	tpetersi@eia.doe.gov
Ethanol	Bruce H. Bawks	202/586-6579	bbawks@eia.doe.gov

Preface

In February 1999, the Administration sent its fiscal year 2000 budget request to the U.S. Congress. It includes more than $4 billion in programs related to climate change. Nearly $1.8 billion of the funding is proposed for tax incentives, research and development, and other spending for the Climate Change Technology Initiative (CCTI). CCTI includes tax credits to serve as incentives for energy efficiency improvements and renewable technologies for buildings, light-duty vehicles, industry, and electricity generation. Other funding covers research, development, and deployment for energy-efficient and renewable technologies, more efficient generating technologies, and carbon sequestration research.

The analysis in this report was undertaken at the request of the Committee on Science of the U.S. House of Representatives. In its request, the Committee asked the Energy Information Administration (EIA) to analyze "the impact of specific policies on the reduction of carbon emissions and their impact on U.S. energy use and prices . . . in the 2008-2012 time frame," as noted in the first letter in the Appendix. The second letter from the Committee specified that EIA "analyze the impact of the President's Climate Change Technology Initiative, as defined for the 2000 budget, on reducing carbon emissions from the levels forecast in the *Annual Energy Outlook 1999* reference case."

The projections and quantitative analysis in this report were conducted primarily using the National Energy Modeling System (NEMS), an energy-economy model of U.S. energy markets designed, developed, and maintained by EIA, which is used each year to provide the projections in the *Annual Energy Outlook*. Chapter 1 of this report provides background discussion of CCTI and the methodology of the analysis. Chapters 2, 3, and 4, respectively, analyze the impacts of the tax credits, research and development funding, and accelerated appliance standards funding proposed in CCTI.

The legislation that established EIA in 1977 vested the organization with an element of statutory independence. EIA does not take position on policy questions. It is the responsibility of EIA to provide timely, high quality information and to perform objective, credible analyses in support of the deliberations of both public and private decisionmakers. This report does not purport to represent the official position of the U.S. Department of Energy or the Administration.

Contents

Executive Summary ix
Tax Incentives x
Research and Development xiv
Efficiency Standards xvi

1. Introduction 1
Tax Incentives 1
Research and Development 3
Efficiency Standards 5
Methods of Analysis 5
Uncertainties 8
Market Barriers 8

2. CCTI Tax Initiatives 11
Introduction 11
Buildings 12
Tax Credits for Energy-Efficient Building Equipment 12
Results 16
Tax Credits for Energy-Efficient New Homes 17
Methodology and Results 19
Tax Credits for Rooftop Solar Equipment 21
Results 23
Industry 24
Background 24
Tax Credit for Combined Heat and Power 25
Methodology 26
Results 30
Transportation 33
Tax Credits for Electric, Electric Hybrid, and Fuel Cell Vehicles 33
Background 33
CCTI Proposals 34
Analytical Approach 35
Results and Discussion 35
Renewable Electricity Generation 41
Background 41
Climate Change Technology Initiative 42
Methodology 43
Results 43
Biomass 43
Wind 46
Conclusion 47

3. Research and Development Support . . . 49
Introduction . . . 49
Buildings . . . 49
Partnership for Advancing Technology in Housing (PATH) . . . 50
Energy Star Products . . . 51
Million Solar Roofs . . . 52
Energy-Efficient Buildings and Energy Smart Schools . . . 53
Federal Energy Management Program . . . 54
Research and Development of Energy-Efficient Buildings Technologies . . . 55
Industry . . . 56
Transportation . . . 57
Partnership for a New Generation of Vehicles . . . 57
Advanced Diesel Technologies for Light and Heavy Trucks . . . 57
Background . . . 57
Analytical Approach . . . 58
Results and Discussion . . . 60
Ethanol from Biomass . . . 65
Electricity Generation . . . 69
Fossil Technologies . . . 69
Efficient Electricity Generating Technologies . . . 69
Background . . . 69
Analysis . . . 70
Carbon Sequestration . . . 72
Renewable Technologies . . . 72
Solar Photovoltaics . . . 72
Solar Thermal . . . 74
Biomass . . . 74
Wind . . . 77
Geothermal . . . 78
Hydropower . . . 79
Nuclear Power . . . 79
Other Energy-Related Research . . . 80
Hydrogen Fuels . . . 80
High-Temperature Superconductivity . . . 81
Conclusion . . . 82

4. Energy-Efficient Appliances and Equipment . . . 83
Introduction . . . 83
Analysis Results . . . 86

Appendix A. Letters from the Committee on Science . . . 87

Tables

ES1. Summary of Climate Change Technology Impacts, 2010 ... xii
ES2. Summary of Climate Change Technology Impacts, 2002-2004 ... xiv
1. Tax Credit Proposal for Energy-Efficient Building Equipment ... 13
2. Cost and Performance Data for CCTI Technologies ... 14
3. Results of the CCTI Tax Incentive for Energy-Efficient Building Equipment ... 16
4. South Region Building Code Characteristics ... 19
5. North Region Building Code Characteristics ... 19
6. Projected Energy Savings and Carbon Emissions Reductions in the CCTI Analysis Case for Energy-Efficient New Homes ... 21
7. Cost Data for CCTI Solar Technologies ... 22
8. CCTI Requirements for Qualifying Combined Heat and Power Systems ... 25
9. Components of Cogeneration Capacity in the Reference Case, 1999 and 2002 ... 26
10. Characteristics of Candidate Cogeneration Systems ... 27
11. Assumed Values for the CHP Investment Payback Acceptance Curve ... 29
12. Projected Effects of the CCTI Tax Credit on Traditional Industrial Cogeneration, 2000-2002 ... 31
13. Projected Effects of the CCTI Tax Credit for Combined Heat and Power (CHP) Systems, 2005 and 2010 ... 32
14. Electric Vehicles Currently Available in U.S. Markets and Announced Dates of New Production Prototypes ... 33
15. Light-Duty Vehicle Sales, 1997-2010 ... 36
16. Light-Duty Vehicle Fuel Consumption, 1997-2010 ... 37
17. Transportation Sector Carbon Emissions by Fuel Type, 1997-2010 ... 37
18. Projected Vehicle Sales and Reductions in Projected Tax Revenues in the CCTI Analysis Case by Vehicle Type, 2002-2006 ... 38
19. Projected Effects of the CCTI Biomass Energy Production Tax Credit, 2005 and 2010 ... 44
20. Projected Effects of the CCTI Biomass Energy Co-firing Tax Credit, 2004, 2005, and 2010 ... 45
21. Projected Effects of the CCTI Wind Energy Production Tax Credit, 2005 and 2010 ... 46
22. Projected Energy Savings and Carbon Emissions Reductions for Successful PATH Program Goals in New Housing, 2005 and 2010 ... 51
23. Projected Electricity Savings and Carbon Emissions Reductions Attributed to the Energy Star TV/VCR Program in the Reference Case, 2005 and 2010 ... 52
24. Projected Energy Savings and Carbon Emissions Reductions for Successful Million Solar Roofs Program ... 53
25. Light Truck Sales, 1997-2010 ... 60
26. Light Duty Vehicle Fuel Consumption, 1997-2010 ... 61
27. Transportation Sector Carbon Emissions by Fuel Type, 1997-2010 ... 61
28. Heavy Truck Diesel Technology Characteristics in the Reference Case ... 63
29. Heavy Truck Diesel Technology Characteristics in the CCTI Analysis Case ... 63
30. Comparison of Reference Case and CCTI Case Results ... 63
31. Market Penetration of CCTI Proposal Technologies in the CCTI Analysis Case ... 64
32. Total CCTI Light Truck and Heavy Truck Diesel Technology Summary, 2005 and 2010 ... 65
33. Ethanol Consumption and Resulting Carbon Emissions Reductions in the Reference Case, 1997, 2005, and 2010 ... 67
34. Projected Uses of Ethanol in the Reference Case, 1997, 2005, and 2010 ... 68
35. Office of Fossil Energy CCTI Funding, 1999 and 2000 ... 69
36. Carbon Emissions for Fossil Generating Technologies ... 71
37. Biomass Power Systems Budget ... 75
38. Effective Dates of Appliance Efficiency Standards, 1988-2001 ... 84
39. Proposal for Possible Accelerated Minimum Efficiency Standards Affecting Buildings ... 85
40. Comparison of Results: Accelerated Standards Process ... 86

Executive Summary

In February 1999, the Administration's fiscal year 2000 budget request was sent to the U.S. Congress, which includes more than $4 billion in programs related to climate change. Nearly $1.8 billion of the funding is tax incentives, research and development, and other spending for the Climate Change Technology Initiative (CCTI). CCTI includes tax credits to serve as incentives for energy efficiency improvements and renewable technologies for buildings, light-duty vehicles, industry, and electricity generation. Other funding covers research, development, and deployment for energy-efficient and renewable technologies, more efficient generating technologies, and carbon sequestration research. Although the tax incentives are new initiatives, many of the other programs are continuations of ongoing research, development, and deployment programs. The total budget request for CCTI programs is almost $1.4 billion for research, development, and deployment, representing an increase of $347 million over the estimated fiscal year 1999 budget, and nearly $0.4 billion for tax incentives.

At the request of the U.S. House of Representatives Committee of Science, the Energy Information Administration (EIA) conducted an analysis of the potential impacts of CCTI, relative to the baseline energy projections in the *Annual Energy Outlook 1999* (*AEO99*)[1]. This analysis was conducted primarily using the National Energy Modeling System (NEMS),[2] EIA's energy-economic modeling system of domestic energy markets. This analysis discusses all programs in CCTI with the exception of $4 million proposed for electricity restructuring at the Environmental Protection Agency (EPA), management, planning, and analysis for the Department of Energy (DOE) and EPA, and the carbon sequestration programs within EPA and the Department of Agriculture (USDA). The analysis primarily focuses on the tax incentives proposed in CCTI, which are new initiatives, because it is not possible to link research and development expenditures directly to program results or to separate the incremental funding requested for fiscal year 2000 from the ongoing program expenditures. As a result, the research and development programs are addressed qualitatively, by analyzing their impact in the *AEO99* reference case, or by analyzing the potential impacts if certain program goals are achieved.

Although NEMS represents energy-consuming and producing technologies with a high degree of detail, the pace of technology development and penetration remains a major uncertainty. In projecting the future of energy markets, EIA relies upon engineering evaluations of the availability, costs, and characteristics of new technologies, which assume continuing patterns of research and development; however, it is not possible to foresee with certainty how energy-using technologies will develop in the future. Not only must a technology be developed, but it also must penetrate the market to be successful. EIA analyzes the empirical evidence to derive estimates of price elasticities

[1]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).
[2]Energy Information Administration, *National Energy Modeling System: An Overview*, DOE/EIA-0581 (Washington, DC, February 1998).

and consumer preferences to evaluate the speed and magnitude of the consumers' reaction to changes in energy prices or improvements in energy efficiency by purchasing more efficient technologies.

Tax Incentives

CCTI proposes tax credits for buildings, vehicles, industry, and renewable electricity generation to lower the initial costs of more energy-efficient and renewable technologies. The Administration estimates the revenue impact of the credits as $383 million in fiscal year 2000 and $3.6 billion over a period of five years. Although these tax credits are in effect for only a few years, the intent is to encourage the penetration of the technologies, reducing costs and creating a more mature market.

- *Buildings*

  - *Tax Credits for Energy-Efficient Homes.* A $1,000 tax credit for new homes purchased between 2000 and 2001 that are at least 30 percent more efficient than the 1998 International Energy Conservation Code (IECC), a $1,500 credit for homes between 2000 and 2002 that are at least 40 percent more efficient, and a credit of $2,000 for homes between 2000 and 2004 that are at least 50 percent more efficient.

  - *Tax Credits for Energy-Efficient Equipment in Existing Homes and Buildings.* A tax credit of 10 percent, up to $250 per unit, for electric heat pumps, central air conditioners, and advanced natural gas water heaters purchased in 2000 and 2001 meeting specified efficiency levels and a 20-percent credit for purchases between 2000 and 2003 of fuel cells, electric heat pump hot water heaters, electric heat pumps, central air conditioners, advanced natural gas water heaters, and natural gas heat pumps meeting specified efficiency levels. The cap is $500 per kilowatt for fuel cells, $1,000 per unit for natural gas heat pumps, and $500 per unit for all other equipment.

  - *Tax Credits for Rooftop Solar Systems.* A 15-percent tax credit, subject to a cap, for rooftop photovoltaic systems installed between 2000 and 2006 and solar water heating systems installed from 2000 and 2004. The cap is $2,000 for the photovoltaic systems and $1,000 for the solar water heating systems.

- *Transportation*

  - *Tax Credits for Electric Vehicles and Fuel Cell Vehicles.* The current 10-percent tax credit, subject to a $4,000 cap, for the purchase of qualified electric vehicles and fuel cell vehicles is scheduled to begin to phase down in 2002, phasing out by 2005; however, the proposal would extend the credit at its full level through 2006.

  - *Tax Credits for Highly Fuel-Efficient Hybrid Vehicles.* Tax credits of $1,000 for qualifying hybrid vehicles, including cars, minivans, sport utility vehicles, and pickup trucks, purchased from 2003 to 2004 that are at least one-third more fuel efficient than a comparable vehicle in the same class; $2,000 for hybrid vehicles from 2003 to 2006 that are at least two-thirds more efficient; $3,000 for hybrid vehicles from 2004 to 2006 that are at least twice as efficient; and $4,000 for hybrid vehicles from 2004 to 2006 that are at least three times as efficient.

- *Industry*

  - *Tax Credits for Combined Heat and Power Systems.* A tax credit of 8 percent for qualified combined heat and power systems larger than 50 kilowatts, installed between 2000 and 2002. Qualified systems would produce at least 20 percent thermal and at least 20 percent electrical or mechanical power. Systems with electrical capacity higher than 50 megawatts would need a total efficiency exceeding 70 percent, and smaller systems would need at least a 60-percent efficiency.

- *Renewable Energy Electricity Generation*

  - *Tax Credits for Wind Generation.* The current tax credit of 1.5 cents per kilowatthour, which is inflation-adjusted, for systems placed in service before July 1, 1999, is extended to systems placed in service before July 1, 2004.

  - *Tax Credits for Biomass Generation.* The current tax credit of 1.5 cents per kilowatthour, which is inflation-adjusted, for systems placed in service before July 1, 1999, is extended to systems placed in service before July 1, 2004. In addition, the definition of biomass systems eligible for the credit is extended to include certain forest-related, agricultural, and other sources, and a 1.0-cent-per-kilowatthour tax credit, adjusted for inflation, is added for electricity generated by coal plants with biomass cofiring through June 30, 2004.

Table ES1 presents the impacts of the tax credits in terms of energy savings and reductions in carbon emissions, relative to the reference case. Where possible, an estimate of the tax revenue implications is provided and compared to the Administration estimates. The year 2010 is the focus because of the carbon reduction targets in the Kyoto Protocol. Some of the technologies covered by the tax credits are likely to be added even without the credits and are included in the reference case. However, the tax credits are applied to both the units that are added as a result of the credits and the units that would be added without the credits, which become unintended beneficiaries of the tax credits. The revenue impacts include all units eligible for the credits.

Table ES1. Summary of Climate Change Technology Impacts, 2010

CCTI Initiative	Reduction[4] in Direct Energy Use[1] (Trillion Btu)	Reduction[4] in Carbon Emissions[2] (Million Metric Tons)	Consumer Annual Energy Expenditure Savings[4] (Million 1998 Dollars)	EIA's Expected Direct Cost to Treasury/ Government, Cumulative, 2000-2004 (Million Dollars)	Administration's Expected Direct Cost to Treasury/ Government, Cumulative, 2000-2004 (Million Dollars)
Tax Credits					
Buildings					
- Energy-Efficient Equipment	17.3	0.8	391.2	61.6[8]	1,533
- Energy-Efficient New Homes	2.76	0.1	34.7	540	429
- Rooftop Solar Equipment	0.0	0.0	0.0	—[10]	132[6]
Industrial Sector					
- Combined Heat and Power Systems	—[11]	0.15	37.6	85 to 125	300
Transportation Sector					
- Electric, Fuel cells and Electric Hybrid	42.3	0.8	462.6	840[9]	900[9]
Wind and Biomass	—	—	—	—	300[5]
- Wind	5.7	0.1	<1	104	—
- Biomass Generation	27.5	0.6	-100	152	—
- Biomass Co-firing	0	0[7]	0	—[12]	—
Accelerated Buildings Standards[3]	143.9	5.2	2,333.5	NA	NA

[1]For the wind and biomass tax credits, the change represents the reduction in fossil energy use for electricity generation.
[2]A marginal carbon factor to estimate the reductions in carbon emissions.
[3]These standards are from American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the U.S.* (Washington, DC, August 1998).
[4]Reductions are relative to the reference case in Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).
[5]Total cost for all three wind and biomass programs.
[6]Cost estimates are for 2000 through 2004 although the proposed tax credit for photovoltaic systems extends through 2006.
[7]The reduction in carbon emissions is .4 million metric tons in 2004; there is no biomass co-firing after the tax credit is eliminated in 2004.
[8]The cost estimates are only for natural gas heat pumps.
[9]The cost estimates are for 2002 through 2006.
[10]Although some equipment is installed in the reference case and would receive the credit, the cost cannot be calculated because equipment owned by utilities and government entities would not be eligible for the credit, and ownership cannot be identified.
[11]In this initiative, cogenerated electricity substitutes for purchased electricity. Also, total site use increases because of additional natural gas consumption.
[12]Cost estimate forthcoming.

In 2010, the tax credits for buildings, industrial, and transportation reduce energy consumption by 62.4 trillion Btu, relative to baseline consumption of nearly 111 quadrillion Btu. In addition, the tax credits for wind and biomass generation reduce fossil energy consumption for electricity generation by 33.2 trillion Btu. In the reference case, carbon emissions are projected to reach 1,790 million metric tons in 2010, which is reduced by 2.6 million metric tons as a total of the individual impacts of the tax credits. Although the tax credits reduce the initial costs of purchasing the applicable equipment, the analysis assumes that consumers will continue to make decisions as has been historically observed. Consumers are typically reluctant to invest in more expensive technologies with long payback periods to recover the incremental costs. In addition, energy efficiency is only one of many attributes that consumers consider when purchasing new energy-equipment or buildings.

Tax credits of longer duration or higher value could encourage greater penetration of the technologies by making them more economically competitive to consumers. The timing of the tax credits is also a key factor in their impacts. For example, the tax credit for combined heat and power systems applies only to systems installed between 2000 and 2002. Since 18 to 36 months are required to plan, design, and install new capacity, there is not much opportunity for incremental investments in the systems. In the *AEO99* reference case, biomass gasification is assumed to be commercially available in 2005. For this analysis, it is assumed that industry would respond to the tax credit by accelerating the development of the technology to 2004; however, since the credit expires in 2004, the impact is limited. Similarly, the tax credit for fuel cell vehicles extends only through 2006, when the technology becomes commercially available.

Table ES2 shows the impacts of the tax credits in earlier years, 2002 to 2004. The tax credits for energy-efficient buildings equipment and biomass co-firing have greater impacts on carbon emissions in the earlier years, which decline as the credits expire. The biomass generation credit has no impact until 2004 because biomass gasification is not available until then. There is also limited impact from the transportation tax credits in the earlier years because of the limited availability of the eligible technologies.

Table ES2. Summary of Climate Change Technology Impacts, 2002-2004

CCTI Initiative	2002 Reduction[3] in Direct Energy Use[1] (Trillion Btu)	2002 Reduction[3] in Carbon Emissions[2] (Million Metric Tons)	2003 Reduction[3] in Direct Energy Use[1] (Trillion Btu)	2003 Reduction[3] in Carbon Emissions[2] (Million Metric Tons)	2004 Reduction[3] in Direct Energy Use[1] (Trillion Btu)	2004 Reduction[3] in Carbon Emissions[2] (Million Metric Tons)
Tax Credits						
Buildings						
- Energy-Efficient Equipment	19.30	1.20	25.00	1.50	25.10	1.40
- Energy-Efficient New Homes	1.01	0.03	1.92	0.06	2.76	0.09
- Rooftop Solar Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Sector						
- Combined Heat and Power Systems	—[4]	0.15	—[4]	0.15	—[4]	0.15
Transportation Sector						
- Electric, Fuel cells and Electric Hybrid	0.00	0.00	4.10	0.06	6.30	0.09
Wind and Biomass						
- Wind	0.80	0.02	0.90	0.02	1.10	0.02
- Biomass Generation[5]	0.00	0.00	0.00	0.00	24.50	0.50
- Biomass Co-firing	123.00	3.00	175.00	4.40	175.00	4.40

[1]For the wind and biomass tax credits, the change represents the reduction in fossil energy use for electricity generation.
[2]A marginal carbon factor to estimate the reductions in carbon emissions.
[3]Reductions are relative to the reference case in Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).
[4]In this initiative, cogenerated electricity substitutes for purchased electricity. Also, total site use increases because of additional natural gas consumption.
[5]Technology is not available until 2004.

Research and Development

CCTI also includes nearly $1.4 billion of funding in the fiscal year 2000 budget request for research, development, and deployment of more energy-efficient and renewable energy and for research into carbon sequestration. More than $1.1 billion is requested for programs within DOE, with additional funding for EPA and the Departments of Housing and Urban Development (HUD), Commerce, and USDA. In addition to developing new technologies, some programs aim to reduce the costs and improve the operating characteristics of existing technologies, making them more economically competitive with conventional technologies. Other initiatives include programs to encourage the deployment of new technologies, such as consultations, partnerships, and voluntary programs.

- *Buildings*. Programs include cooperative efforts with the building industry to improve the energy-efficiency of homes, funding for new Energy Star products, the development of energy-efficient technologies, and partnerships to improve the energy efficiency of commercial buildings and schools.

- *Transportation.* Proposed funding includes the Partnership for a New Generation of Vehicles program, partnerships to develop advanced diesel cycle engine technologies for pickup trucks, vans, and sport utility vehicles and to improve the fuel efficiency of new heavy trucks, and the continued development of ethanol and other biofuels.

- *Industry.* Programs include partnerships to develop more energy-efficient technologies for the most energy-intensive industries and the continuing development of cogeneration systems and elimination of barriers for combined heat and power technologies

- *Electricity Generation.* Funding includes continued development for solar energy, biomass power, wind energy, geothermal power, and hydropower; the Renewable Energy Production Incentive, renewable energy demonstration projects; the International Solar Program; improvements for the quality and reliability of power service; distributed generation; hydrogen production and storage; superconducting technology; life extension of nuclear power plants; and development of more efficient coal and natural gas generation.

- *Carbon Sequestration.* This program funds research into the capture and storage of carbon dioxide in underground geological structures or in the deep ocean.

The impacts of research and development funding for new technologies is not possible to quantify in the same manner as the tax incentives. Some of the proposed technologies may only achieve benefits in a very long time frame or may not achieve success at all, but predicting winning technologies is highly speculative. A direct link cannot be established between levels of funding for research and development and specific improvements in the characteristics and availability of energy technologies. In addition, successful development of new technologies may not lead to immediate penetration in the marketplace. Low prices for fossil energy and conventional technologies, unfamiliarity with the use and maintenance of new products, and uncertainties concerning the reliability and further development of new technologies are all factors that may slow technology penetration.

It is also difficult to analyze the impacts of information programs, voluntary initiatives, and partnerships on realized technology development and deployment. Some voluntary programs appear to have achieved some success, such as Energy Star, but the benefits of past efforts are difficult to quantify and equally difficult to quantify for the future.

This analysis addresses these initiatives by discussing the current state of development of the technologies and the economics of their development and deployment. For several of these programs, the potential impacts are analyzed by assuming that program goals are achieved, then deriving the impacts on energy consumption and emissions, or examining the historical impact of ongoing technology development. In the *AEO99* reference case projections, natural gas generation plants are expected to dominate new capacity additions over the next 10 to 15 years, although advanced coal plants become economical after 2010. Renewable electricity generation increases steadily in the reference case projections, particularly biomass, wind, and to a lesser extent geothermal generation; however, solar thermal and photovoltaic technologies do not contribute significantly within the time frame of the analysis, and no new hydropower capacity is projected. In the transportation sector, alternative-fueled vehicle sales account for about 8 percent of the light-duty vehicle sales in 2020, with alcohol flex-fuel vehicles and dedicated electric vehicles each accounting for nearly one-fourth of the market; however, nearly all the penetration of electric vehicles is driven by mandates.

Analysis indicates that some of the programs for the development of renewable technologies may hold promise, as well as some buildings programs if the program goals can be achieved. Stock turnover can slow the penetration of some of the improved technologies, even if successful, so that significant changes in the average stock of equipment may take a long time. In addition, some of the technologies may have non-economic barriers to widespread acceptance, such as unfavorable impressions of older diesel vehicles or limitations on hydropower sites. Some of the CCTI programs may have much longer-term benefits, partly due to slow stock turnover, but also because some of the research and development programs are likely to achieve success later in or beyond the 2020 horizon of the analysis.

Efficiency Standards

Within the building technologies program, additional funding is provided to DOE to accelerate the lighting and appliance efficiency standards program in order to encourage the deployment of more energy-efficient appliances and equipment. Historically, efficiency standards have been successful in improving energy efficiency. Program goals include the development of new standards for fluorescent lamp ballasts, water heaters, and clothes washers, with test procedures for residential central air conditioners and heat pumps, distribution transformers, commercial heating, ventilation, and air conditioning, and water heaters.

Because future standards are not specified, the potential impact is analyzed by evaluating the impacts of the standards in the American Council for an Energy-Efficient Economy study *Approaching the Kyoto Targets: Five Key Strategies for the U.S.*[3] The results are also presented in Table ES1. In 2010, it is projected that energy consumption would be reduced by 143.9 trillion Btu and carbon emissions by 5.2 million metric tons. Because of the energy efficiency improvements, consumers would save $2,334 million (1998 dollars) in 2010 alone.

This analysis does not necessarily include all costs of technology development and deployment. For example, the full costs of developing and manufacturing new technologies, including costs to the private sector, and infrastructure costs are not included. Certain programs are analyzed by assuming program goals or standards that may not

[3]American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the U.S.* (Washington, DC, August 1998).

necessarily be economic within the time frame of the analysis, leading to additional costs that are not incorporated into a decisionmaking process. However, in addition to reductions in energy consumption, consumer expenditures for energy, and carbon emissions, there may be other benefits to these programs that are not evaluated. Potential ancillary benefits include improvements in air quality due to reductions in other emissions, energy security from lower energy consumption, international competitiveness as a result of improved efficiency, and revenues from the deployment of more advanced technologies to other countries.

There are a number of barriers to technology penetration that may account for seemingly cost-effective technologies to penetrate slowly. Lack of information about new technologies which may be overcome with information programs. Subsidies or regulated prices may hold energy prices artificially low and hamper the penetration of technologies. Builders and homeowners or tenants may have different incentives for energy efficiency. It may be difficult for the builder or landlord to recover the additional costs for more expensive, energy-efficient equipment from a buyer or tenant who may not value energy efficiency highly. Conversely, the buyer or tenant who will be paying the energy bills may not readily have the option to make the equipment choices. Even if energy consumers are aware of potential cost savings from a more efficient technology, they may have preference for other equipment characteristics, for example, valuing vehicle size over efficiency. Also, consumers may prefer a relatively short payback period for investments in energy-consuming technologies. Technology penetration can also be slowed by uncertainties about reliability, installation and maintenance, availability of the next generation of the technology, and necessary infrastructure.

These barriers can be addressed by information programs, collaborative efforts for development and diffusion, research and development to improve the technologies and reduce costs, and incentives to enhance the cost effectiveness of new technologies, which all may help to encourage earlier penetration of technologies. Subsequently, the initial penetration may have the additional impact of reducing costs through learning, establishing the infrastructure, and increasing familiarity with new technologies. Finally, equipment standards and other mandates such as renewable portfolio standards can also lead to earlier penetration of new, more advanced technologies.

1. Introduction

In February 1999, the Administration's fiscal year 2000 budget request was sent to the U.S. Congress, which includes more than $4 billion in programs related to climate change. Nearly $1.8 billion of the funding is tax incentives, research and development, and other spending for the Climate Change Technology Initiative (CCTI). CCTI includes tax credits to serve as incentives for energy efficiency improvements and renewable technologies for buildings, light-duty vehicles, industry, and electricity generation. Other funding covers research, development, and deployment for energy-efficient and renewable technologies, more efficient generating technologies, and carbon sequestration research. Although the tax incentives are new initiatives, many of the other programs are continuations of ongoing research, development, and deployment programs. The total budget request for CCTI programs is almost $1.4 billion for research, development, and deployment, representing an increase of $347 million over the estimated fiscal year 1999 budget, and nearly $0.4 billion for tax incentives.

Additional programs related to climate change include the U.S. Global Change Research Program, international assistance, and programs with climate change co-benefits, for example, weatherization and State energy grants. There are additional initiatives supported by the Administration that have a primary or ancillary purpose in reducing emissions. These include, but are not limited to, establishing a program for early action in reducing emissions, industry consultations, electricity restructuring, and changes in Federal procurement to increase energy efficiency and the use of renewable energy technologies in the Federal government. With the exception of electricity restructuring, the impacts of these programs cannot be quantified, and none of these programs are discussed in this analysis. This analysis discusses all programs in CCTI with the exception of $4 million proposed for electricity restructuring at the Environmental Protection Agency (EPA), management, planning, and analysis for the Department of Energy (DOE) and EPA, and the carbon sequestration programs within EPA and the Department of Agriculture (USDA). This report focuses on the tax incentives proposed in CCTI, which are new initiatives, because it is not possible to link research and development expenditures directly to program results or to separate the incremental funding requested for fiscal year 2000 from the ongoing program expenditures.

Tax Incentives

The proposed tax incentives include tax credits for buildings, vehicles, industry, and renewable electricity generation, which lower the initial costs of more energy-efficient and renewable technologies. The revenue impact of these tax credits as estimated by the Administration is $383 million in fiscal year 2000 and $3.6 billion over a period of five years. Although these tax credits are short term in nature, the longer-term purpose is to encourage the use of these technologies, reducing production costs and creating a more mature market.

- *Buildings*

  - *Tax Credits for Energy-Efficient Homes*—graduated tax credits for the purchase of new homes that are at least 30 percent more energy efficient than the 1998 International Energy Conservation Code (IECC). Specifically, a $1,000 tax credit for new homes between 2000 and 2001 that are at least 30 percent more efficient, a $1,500 credit for homes between 2000 and 2002 that are at least 40 percent more efficient, and a credit of $2,000 for homes between 2000 and 2004 that are at least 50 percent more efficient than the IECC standard.

  - *Tax Credits for Energy-Efficient Equipment in Existing Homes and Buildings*—tax credits, subject to caps, for electric heat pump and natural gas water heaters, electric and natural gas heat pumps, advanced central air conditioners, and fuel cells. A credit of 10 percent, up to $250 per unit, is allowed for electric heat pumps, central air conditioners, and advanced natural gas water heaters purchased in 2000 and 2001 meeting specified efficiency levels. A 20-percent credit is proposed for purchases between 2000 and 2003 of fuel cells, electric heat pump hot water heaters, electric heat pumps, central air conditioners, advanced natural gas water heaters, and natural gas heat pumps meeting specified efficiency levels. The cap is $500 per kilowatt for fuel cells, $1,000 per unit for natural gas heat pumps, and $500 per unit for all other equipment.

  - *Tax Credits for Rooftop Solar Systems*—a 15-percent tax credit, subject to a cap, for rooftop photovoltaic systems installed between 2000 and 2006 and solar water heating systems installed from 2000 and 2004. The cap is $2,000 for the photovoltaic systems and $1,000 for the solar water heating systems.

- *Transportation*

  - *Tax Credits for Electric Vehicles and Fuel Cell Vehicles*—the current 10-percent tax credit, subject to a $4,000 cap, for the purchase of qualified electric vehicles and fuel cell vehicles is scheduled to begin to phase down in 2002, phasing out by 2005; however, the proposal would extend the credit at its full level through 2006.

  - *Tax Credits for Highly Fuel-Efficient Hybrid Vehicles*—graduated tax credits for qualifying hybrid vehicles, including cars, minivans, sport utility vehicles, and pickup trucks. The credits are $1,000 for vehicles purchased from 2003 to 2004 that are at least one-third more fuel efficient than a comparable vehicle in the same class; $2,000 for vehicles from 2003 to 2006 that are at least two-thirds more efficient; $3,000 for vehicles from 2004 to 2006 that are at least twice as efficient; and $4,000 for vehicles from 2004 to 2006 that are at least three times as efficient.

- *Industry*

  - *Tax Credits for Combined Heat and Power Systems*—8-percent tax credits for qualified combined heat and power systems larger than 50 kilowatts, installed between 2000 and 2002. Qualified systems would produce at least 20 percent thermal and at least 20 percent electrical or mechanical power. Systems with electrical capacity higher than 50 megawatts would need a total efficiency exceeding 70 percent, and smaller systems would need at least a 60-percent efficiency.

- *Renewable Energy Electricity Generation*

  - *Tax Credits for Wind Generation*—the current tax credit of 1.5 cents per kilowatthour, which is inflation-adjusted, for systems placed in service before July 1, 1999, is extended to systems placed in service before July 1, 2004.

  - *Tax Credits for Biomass Generation*—the current tax credit of 1.5 cents per kilowatthour, which is inflation-adjusted, for systems placed in service before July 1, 1999, is extended to systems placed in service before July 1, 2004; the definition of biomass systems eligible for the credit is extended to include certain forest-related, agricultural, and other sources; a 1.0-cent-per-kilowatthour tax credit, adjusted for inflation, is added for electricity generated by coal plants with biomass cofiring through June 30, 2004.

Research and Development

In addition to the tax incentives, CCTI also includes nearly $1.4 billion of funding in the fiscal year 2000 budget request for research, development, and deployment of energy-efficient, renewable energy, and clean coal technologies and for research into carbon sequestration. More than $1.1 billion is requested for programs within DOE, with additional funding for EPA and the Departments of Housing and Urban Development (HUD), Commerce, and USDA. The energy-related programs include buildings, transportation, industry, and electricity generation initiatives.

In addition to inventing and developing new technologies, some research and development programs aim to reduce the costs and improve the operating characteristics of existing technologies, making them more economically competitive with conventional technologies. Some of the proposed technologies are speculative and may achieve benefits in a very long time frame or may not achieve success at all. Other initiatives include programs to encourage the deployment of new technologies, such as consultations, partnerships, and voluntary programs. Although these programs may be low cost, the benefits of past efforts are difficult to quantify and equally difficult to quantify for the future. Successful development of new technologies does not guarantee penetration. Low prices for fossil energy and conventional technologies, unfamiliarity with the use and maintenance of new products, and uncertainties concerning the reliability and further development of new technologies, among other reasons, can work to slow technology penetration.

- *Buildings*

  - *Partnership for Advancing Technology in Housing*—a cooperative effort by DOE, HUD, EPA, and the Federal Energy Management Agency with the building industry to improve the energy-efficiency of homes with the goal of building 2,000 highly energy-efficient and cost-effective houses. The goals are to make new homes 50 percent more efficient within a decade and retrofit 15 million homes to make them 30 percent more efficient.

  - *Energy Efficient Appliances and Equipment*—DOE and EPA programs to develop new Energy Star products and increase funding for the development of energy-efficient technologies

  - *Energy-Efficient Commercial Buildings*—DOE and EPA partnership with industry for research, development, and deployment of technologies and practices to improve the energy efficiency of commercial buildings

  - *Energy Smart Schools*—programs to improve energy efficiency of schools

- *Transportation*

  - *Partnership for a New Generation of Vehicles (PNGV)*—an ongoing government partnership with industry to develop a prototype mid-size automobile with an efficiency of 80 miles per gallon by 2004

  - *Light and Heavy Trucks*—government and industry partnerships to develop advanced diesel cycle engine technologies for pickup trucks, vans, and sport utility vehicles with a 35-percent efficiency improvement by 2002 and engine and vehicle technologies to improve the fuel efficiency of new heavy trucks from 5.3 miles per gallon to 12 miles per gallon.

  - *Biofuels*—continuing programs with USDA to develop the technologies to convert agricultural products to ethanol and other biofuels

- *Industry*

  - *Industries of the Future*—DOE partnership programs with the most energy-intensive industries to develop more energy-efficient technologies

  - *Industrial Cogeneration*—continuing DOE programs for the development of cogeneration systems and combined efforts with EPA to eliminate barriers to the dissemination of combined heat and power technologies

- *Electricity Generation*

  - *Renewable Technologies*—continuing research and development solar energy, biomass power, wind energy, geothermal power, and hydropower

  - *Deployment*—funding for the Renewable Energy Production Incentive, renewable energy demonstration projects, and the International Solar Program

  - *Transmission and Distribution*—development of storage and power quality systems to improve the quality and reliability of power service and continuing development of distributed generation

  - *Hydrogen*—acceleration of research for hydrogen production and storage

  - *High Temperature Superconductivity*—continuing support for the development of superconducting technology

  - *Nuclear Energy*—funding for programs to extend the useful life of nuclear power plants

  - *Fossil Energy*—programs to improve the efficiency of coal and natural gas generation

- *Carbon Sequestration*—research into the capture and storage of carbon dioxide in underground geological structures or in the deep ocean.

Efficiency Standards

Within the building technologies program, additional funding is provided to DOE to accelerate the lighting and appliance efficiency standards program in order to encourage the deployment of more energy-efficient appliances and equipment. Historically, efficiency standards have been successful in improving energy efficiency. It is proposed that new standards be developed for fluorescent lamp ballasts, water heaters, and clothes washers, with test procedures for residential central air conditioners and heat pumps, distribution transformers, commercial heating, ventilation, and air conditioning, and water heaters.

Methods of Analysis

At the request of the U.S. House of Representatives Committee of Science, the Energy Information Administration (EIA) conducted an analysis of the potential impacts of CCTI. This analysis was conducted primarily using the

National Energy Modeling System (NEMS),[4] the energy-economic modeling system of domestic energy markets developed and maintained by the Office of Integrated Analysis and Forecasting within EIA. With some minor modifications and ongoing enhancements, the version of NEMS in this analysis is that used for the projections in *Annual Energy Outlook 1999* (*AEO99*),[5] published in December 1998. In addition to providing baseline projections of U.S. energy markets, NEMS is used to provide analysis of energy issues at the request of the U.S. Congress, other parts of DOE, and other government agencies. Additional offline analysis utilized a building code model and building simulation model, both developed by DOE, to evaluate the tax credits for new energy-efficient homes.

For most of the energy-consuming and producing sectors of the economy, NEMS includes individual technologies, characterizing them by capital and operating costs, efficiencies, years of availability, and other relevant attributes. Therefore, NEMS can directly analyze the penetration of new technologies and the impacts of changes in the characteristics of technologies.

For this CCTI analysis, the tax credits for energy-efficient homes and buildings equipment; rooftop solar systems; electric, fuel cell and hybrid vehicles; combined heat and power systems; and wind and biomass electricity generation reduce the initial costs of purchasing the applicable equipment over the years specified in the proposals. Also, in analyzing the impact of the tax credit for fuel cell vehicles, the commercial availability of these vehicles was advanced from 2010 to 2006, based on the announcement of a prototype vehicle in 2004, assuming commercial availability in 2006. With the exception of some reduction in the costs of the advanced generation technologies, the analysis does not include ancillary benefits that might accrue in reducing the costs with increasing penetration. It is recognized that cost is not the only factor in consumer decisionmaking; however, this analysis assumes that consumer behavior will remain similar to that derived from empirical evidence because there is no basis for assuming a fundamental change in consumer behavior. Consumer behavior has worked against the adoption of more efficient technologies in the past due to the value placed on attributes other than efficiency; however, future consumer behavior could shift to favor novel technologies or technologies that would benefit the climate if there is widespread acceptance of a need to improve energy efficiency or reduce emissions. However, the incentives and programs in CCTI are unlikely to produce such changes because of the immediate timing of the tax incentives and the overall level of funding for CCTI.

The portion of CCTI that includes funds for research, development, and deployment of new technologies is more difficult to quantify. In general, a direct link cannot be established between levels of funding for research and development and specific improvements in the characteristics and availability of energy technologies. Similarly, it is difficult to quantify a link between information programs and other programs for voluntary initiatives and partnerships for technology development with realized technology development and deployment. As a result, the research and development components of CCTI are approached differently than the tax incentives.

[4]Energy Information Administration, *National Energy Modeling System: An Overview*, DOE/EIA-0581 (Washington, DC, February 1998).
[5]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).

Many of these research and development programs are addressed in qualitative terms in this analysis, discussing the current state of development of the relevant technologies and the economics of their development and deployment. For several of these programs, the potential impacts are analyzed by looking at possible technology improvements that could be achieved. The buildings program for energy-efficient appliances and equipment, which includes acceleration of lighting and appliance efficiency standards and new Energy Star products, is analyzed by evaluating the impacts of the standards in the American Council for an Energy-Efficient Economy study *Approaching the Kyoto Targets: Five Key Strategies for the U.S.*,[6] combined with the new Energy Star programs for televisions and video cassette recorders, and the goal of the Million Solar Roofs program. The program for the development of more energy-efficient technologies for light and heavy trucks is evaluated by assuming that the program goals for advanced diesel technologies for light trucks and for a variety of fuel-savings technologies for heavy trucks will be achieved and evaluating the economics of their penetration. In a similar fashion, the Partnership for Advancing Technology in Housing (PATH), which has a goal of improving the energy efficiency of homes, is analyzed by assuming that the goals for new housing construction are fully realized; however, the costs of achieving those highly efficient homes are not evaluated or incorporated into a decisionmaking process.

For each tax incentive or other program that is evaluated quantitatively, the impact is analyzed by using the relevant sector of NEMS in a standalone mode. The results are presented in terms of energy savings and reductions in carbon emissions from the sector, relative to the reference case, along with other key indicators from the sector. Where possible, an estimate of the tax revenue implications is also provided and compared to the estimates in the budget submission. It is important to recognize that all results are presented as incremental changes to the reference case. Where CCTI encompasses ongoing research, development, and deployment programs that are already included in the reference case of *AEO99*, the impacts of these ongoing trends are not evaluated.

It is also possible that some of the more efficient technologies included in the CCTI tax incentives would be added even in the absence of the incentives. The benefits of the tax incentives are applied equally to both the units that are added incrementally as a result of the incentives and the units that would be added even in the baseline, which become unintended beneficiaries of the tax incentives. Where applicable, this analysis identifies the incremental units that are introduced as a result of the CCTI provisions.

The presentation of the results focuses on the year 2010, because of the carbon reduction targets in the Kyoto Protocol, and also on 2005, because of the tax credits, none of which extend beyond 2006. Some of the CCTI programs may have much longer-term benefits. Because of stock turnover, which can be very slow, energy-efficient improvements and standards may take a long time to produce significant changes in the average stock of equipment. In addition, some of the research and development programs may have results later in or beyond the 2020 horizon of the analysis. The results are primarily presented in terms of energy savings and carbon reductions. Additional

[6]American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the U.S.* (Washington, DC, August 1998).

benefits that may occur, but are not evaluated, include improvements in air quality due to reductions in other emissions, energy security from lower energy consumption, international competitiveness as a result of improved efficiency, and revenues from the deployment of more advanced technologies to other countries.

As noted above, the PATH program is evaluated by assuming program goals, which may not be economic within the time frame of the analysis. New equipment evaluated for the energy efficiency standards may also lack the economic incentives to enable them to penetrate on their own. These costs and others, such as the full private sector costs of developing and manufacturing new technologies, infrastructure costs, and social costs, are not captured in the analysis.

Uncertainties

It is possible that a standalone analysis of energy-efficiency policies may overstate the potential energy and carbon savings that would occur in a fully integrated analysis of energy markets. In other words, the individual energy sector savings are not necessarily additive. As an example, some policies may encourage the development and deployment of more energy-efficient and/or less carbon-intensive technologies for electricity generation. If concurrent policies encourage energy efficiency in the end-use demand sectors and reduce the demand for electricity, however, there may be less opportunity for the generation sector to grow and invest in the new generation technologies. Therefore, evaluating the combined impacts in an integrated model may be important. In this analysis, however, the individual impacts of the CCTI programs are relatively small and, as a result, the integrated evaluation adds no additional information.

One of the key uncertainties in analyzing the impact of new, more-efficient technologies is consumer price elasticities—to what extent and how quickly energy consumers will react to changes in energy prices or to improvements in the energy efficiency of equipment by purchasing the more efficient technologies. The EIA analysis relies on empirically-derived estimates of price elasticities and consumer preferences to evaluate technology penetration. The pace of technology development is also a major uncertainty. While EIA relies on engineering evaluations of the availability, costs, and characteristics of new technologies assuming continuing patterns of research and development, it is acknowledged that it is not possible to foresee with certainty how energy-using technologies will develop in the future.

Market Barriers

In order for new, more advanced technologies to enter the marketplace, they must be developed, but also must penetrate. While some programs in the CCTI are aimed at the basic research and development of more efficient or renewable technologies, others are focussed on the diffusion and deployment of the technologies.

There are a number of reasons why new technologies may be slow to penetrate. Foremost among these reasons is that new technologies must be cost-effective. Much of the research in new energy technologies such as photovoltaic and wind generation is to reduce the costs of these technologies.

The lack of penetration of technologies that appear cost-effective is often termed market failures; however, more recently, analysts have attempted to separate true market failures from other market barriers. Market failures may result from lack of information about the characteristics of new technologies which may be approached with a variety of information programs. Another difficulty is exemplified by the difference in incentives of builders versus homeowners. To the extent that newer technologies may be more expensive, it may be difficult for the builder or landlord to recover the additional costs from a buyer or tenant who may not value energy efficiency as highly as other characteristics. Conversely, the buyer or tenant who will be paying the energy costs may not readily have the option to make the equipment choices. Finally, artificially lower prices for energy, through subsidies or regulated prices for example, may hamper the penetration of technologies because lower technology costs would be necessary for them to appear cost effective.

Other items may be viewed as market barriers, not failures. Energy consumers may be fully aware of potential cost savings from a more efficient technology but have a preference for other characteristics of equipment they are about to purchase. The current trend for larger, more powerful vehicles is a prime example, but there are many examples of characteristics for vehicles, appliances, and equipment that compete with energy efficiency.

There is also a difference in the perceived payback periods for equipment purchases that varies among consumers. A technology may appear cost effective when the potential fuel cost savings are estimated over a long period of time, but many consumers appear to want a more immediate payback for their higher initial purchase costs, due to a high time value of money. Also, the tendency for homeowners to move frequently works against the purchase of equipment with long payback periods. Finally, there is a high degree of uncertainty on future fuel prices or on the duration of occasional price spikes that does not favor investments in energy savings.

New technology also tends to have a naturally slow penetration for a variety of reasons. These can include uncertainty as to the reliability of the new product, new techniques for installing and maintaining the equipment, uncertainty on the future availability of the next generation of the technology which could represent a major improvement, and infrastructure for the support and maintenance of the technology.

These market failures or barriers can be approached by a number of programs, including those in the CCTI. Information programs, collaborative efforts for development and diffusion, research and development to improve the technologies and reduce costs, and incentives to enhance the cost effectiveness of new technologies may all help to encourage earlier penetration of technologies. Subsequently, the initial penetration may have the additional impact of reducing costs through learning, establishing the infrastructure, and increasing familiarity with new technologies.

Finally, equipment standards and other mandates such as renewable portfolio standards can also bring technologies into the market earlier than they would otherwise. Standards may not be the most efficient policies; however, a cost analysis is not part of this study.

2. CCTI Tax Initiatives

Introduction

The Administration's Climate Change Technology Initiative (CCTI) includes a number of proposed tax incentives that would provide tax credits for buildings, vehicles, industry, and renewable electricity generation. The purpose of the tax credits is to reduce the initial costs of more energy-efficient and renewable technologies, thereby encouraging their adoption earlier than would otherwise occur. The tax credits are short-term incentives, lasting only a few years and extending no later than 2006; however, in addition to their short-term impacts, they are intended to stimulate the use of the technologies, lower costs, and establish a more mature market. The Administration estimates the combined revenue impact of the tax credits at $383 million in fiscal year 2000 and $3.6 billion over a period of 5 years.

In general, the analysis of the tax incentives used the National Energy Modeling System (NEMS),[7] the Energy Information Administration (EIA) model of U.S. energy markets. To evaluate the tax credits for new energy-efficient homes, U.S. Department of Energy (DOE) building code and building simulation models were also used. The proposed tax credits reduce the initial costs of purchasing the applicable equipment over the years specified in the proposals, which serves to make them more cost-effective to consumers making the purchasing decisions.

The results highlight the energy savings and reductions in carbon emissions for each of the tax credits, relative to a reference case based on the *Annual Energy Outlook 1999* (*AEO99*),[8] published in December 1998. Where possible, an estimate of the tax revenue implications is also provided and compared to the Administration estimates. It is likely that the technologies targeted in the CCTI would penetrate to some degree even in the absence of the proposed tax credits; however, those units would receive the tax credit as well as the marginal units that would come on line purely as a result of the credit. Estimates of the magnitude of such unintended beneficiaries are also provided. Another unintended result of the tax credits may be a tendency on the part of purchasers to either delay or accelerate investments in order to receive the credits, an effect not possible to quantify.

---

[7]Energy Information Administration, *National Energy Modeling System: An Overview*, DOE/EIA-0581 (Washington, DC, February 1998).
[8]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).

Buildings

The Clinton Administration's proposed budget for fiscal year 2000 includes a package of proposals aimed at promoting energy efficiency and improving the environment. The CCTI package includes $2.1 billion in targeted tax incentives over 5 years for consumers who purchase energy-efficient products and energy from renewable sources for use in buildings. By offering consumers price reductions on energy-efficient products through reductions in their Federal taxes, the CCTI initiatives are intended to increase demand for the products and, thereby, increase economies of scale in the production process, reduce production and retail costs, and develop a more robust market for the products. The CCTI package also includes $273 million in investments for research, development, and deployment of clean technologies for residential and commercial buildings in fiscal year 2000.

The proposed CCTI tax credits provide incentives for the purchase of more efficient equipment and structures by offering income tax credits for the year in which the equipment or structure was purchased. The Administration estimates reductions in tax revenues of $2.1 billion from fiscal year 2000 through fiscal year 2006 as a result of the proposed initiatives for the buildings sectors. Specific estimates include $1.5 billion in tax incentives for energy-efficient equipment, $429 million for the purchase of new energy-efficient homes, and $132 million for rooftop solar systems.

The EIA has conducted an analysis of the CCTI tax incentive proposals that have the potential to affect levels of energy use and carbon emissions in the buildings sectors. Estimates of the projected impacts were developed by comparing the results from a reference case with results from an analysis case incorporating the proposed tax initiatives. Energy consumption and energy-related carbon emissions were the only effects considered. The reference case included efficiency and price improvements expected under current policy and market conditions. The residential and commercial demand modules of NEMS were used to model the CCTI proposals that could be explicitly represented (tax credits for energy-efficient equipment in existing homes and buildings and tax credits for rooftop solar systems). An off-line analysis using DOE building simulation models and payback analyses was employed to evaluate the potential impacts of the proposed tax credits for energy-efficient new homes. Estimates were developed considering only the buildings sectors, with no analysis of possible feedback effects from other sectors of the economy.

Tax Credits for Energy-Efficient Building Equipment

A two-tier tax incentive program has been proposed to accelerate the development and distribution of energy-efficient technologies, generally providing a 10-percent credit for energy-efficient equipment purchased in 2000 and 2001 and a 20-percent credit for higher efficiency equipment purchased from 2000 through 2003. For example, a small commercial business that is planning to install a new cooling system in the year 2000 could receive either a 10-percent tax credit on the purchase price of a residential-type central air conditioner with a cooling efficiency of 13.5

SEER (Seasonal Energy Efficiency Factor) or a 20-percent tax credit for a central air conditioner with a cooling efficiency of 15 SEER. The specific technologies, requirements for eligibility, and applicable credits of the tax incentive program are shown in Table 1.

Table 1. Tax Credit Proposal for Energy-Efficient Building Equipment

Technology	Minimum Efficiency[a]	Time Frame for Purchase	Tax Credit
Efficient Equipment			
Air-source heat pump	Heating: 9 HSPF Cooling: 13.5 SEER	2000-2001	10% of purchase price up to $250
Central air conditioner	13.5 SEER	2000-2001	10% of purchase price up to $250
Advanced natural gas water heater	0.65 EF	2000-2001	10% of purchase price up to $250
Higher Efficiency Equipment			
Air-source heat pump	Heating: 9 HSPF Cooling: 15.0 SEER	2000-2003	20% of purchase price up to $500
Central air conditioner	15.0 SEER	2000-2003	20% of purchase price up to $500
Advanced natural gas water heater	0.80 EF	2000-2003	20% of purchase price up to $500
Electric heat pump water heater	1.7 EF	2000-2003	20% of purchase price up to $500
Natural gas heat pump	Heating COP: 1.25 Cooling COP: 0.70	2000-2003	20% of purchase price up to $1,000
Fuel cell[b]	Electricity generation: 35% Minimum capacity: 5 kilowatts	2000-2003	20% of purchase price up to $500 per kilowatt of capacity

[a]Units for efficiency measures are presented as given in the Department of the Treasury's explanation of the CCTI proposals: HSPF, Heating Seasonal Performance Factor; SEER, Seasonal Energy Efficiency Rating; EF, Energy Factor; COP, Coefficient of Performance.
[b]Uses an electrochemical process to generate electricity and heat.
Source: U.S. Department of the Treasury, "General Explanations of the Administration's Revenue Proposals" (February 1999).

The tax credit is a percentage of the purchase price not exceeding a specified price limit. The purchase prices of the technologies included in the CCTI proposal are such that, in some instances, the tax credit does not exceed the cap. Table 2 illustrates this point by providing the costs and possible tax credits for equipment of the efficiency levels specified in the proposal. Also provided in Table 2, for comparison purposes, is the cost of the equipment that just meets the current energy efficiency standards and thus would receive no tax credit.

Table 2. Cost and Performance Data for CCTI Technologies

Technology	Efficiency[a]	Cost	Proposed Tax Credit
Air-source heat pump	6.8 HSPF, 10.0 SEER	$4,100	None
	9.0 HSPF, 13.5 SEER	$5,100	$250
	9.0 HSPF, 15.0 SEER	$5,300	$500
Central air conditioner	10.0 SEER	$2,500	None
	13.5 SEER	$2,950	$250
	15.0 SEER	$3,100	$500
Natural gas water heater	0.54 EF	$350	None
	0.66 EF	$779	$78
	0.86 EF	$2,360	$472
Electric water heater	0.88 EF	$350	None
Heat pump water heater	2.60 EF	$1,025	$205
Natural gas furnace/central air conditioner	0.80 AFUE, 10.0 SEER	$3,800	None
Natural gas heat pump	1.4 GCOP, 0.7 GCOP	$8,000	$1,000
Fuel cell	35%	$3,000 per kilowatt[b]	$500 per kilowatt

[a]Heating and cooling efficiency, respectively, are given for heating and cooling combination units. Units for efficiency measures are presented as given in the Department of the Treasury's explanation of the CCTI proposals: HSPF, Heating Seasonal Performance Factor; SEER, Seasonal Energy Efficiency Rating; EF, Energy Factor; COP, Coefficient of Performance.
[b]Source: Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Advanced Adoption Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998). Installed cost is for a phosphoric acid fuel cell ranging in size from 5 to 250 kilowatts of generating capacity.
Sources: Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Reference Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998). Costs are given in 1998 real dollars.

In the NEMS residential and commercial modules, the income tax credit is represented as a direct offset to the cost of the equipment. The costs for each of the affected technologies are reduced only for the years specified in the budget language. Once the tax credit expires, it is no longer subtracted from the cost of the technology. Both the reference case and the CCTI analysis case incorporate cost declines for advanced technologies over time as producers gain experience. The size and duration of the credit in the CCTI case are not considered sufficient to alter the rate of the cost declines. The credit is also believed to be too small to affect general consumer behavior toward energy efficiency or to change the barriers to entry that exist in the marketplace. An example of this market phenomenon is the development of heat pump water heaters in the early 1980s. With the help of government and utility supports, sales of heat pump water heaters peaked at about 8,000 units in 1985. Even with continued utility support, however, the decline in real energy prices and uncertainties regarding the technology caused sales to slip to 2,000 units per year, where they have stabilized.[9] While innovative and aggressive marketing strategies by private firms and

[9]U.S. Department of Energy, Office of Building Equipment, *Market Disposition of High-Efficiency Water Heating Equipment* (Washington, DC, November 1996).

government information programs could enhance the effectiveness of the tax credits by increasing the exposure and consumer awareness of a given technology, the short lead time and limited duration of the proposed incentives make changes in consumer behavior unlikely.

It is clear from Table 2 that the tax credits offered would not significantly change the economics of the investment decision from the consumer's point of view. Historically, consumers have been unwilling to invest in energy-efficient equipment with long payback periods. Short tenancy rates, lack of information, the fact that builders (as opposed to consumers) generally purchase the energy-using equipment, and limited availability of investment funds are just some of the factors that tend to affect purchase decisions.

Most of the technologies included in the CCTI proposal currently retain very small market shares in the residential arena. Natural gas heat pump prices have been high and volatile due to low sales, which currently total under 6,000 units per year. A consortium of 120 gas utilities currently subsidizes the development of the York Triathlon gas heat pump in an effort to increase sales to a level at which economies of scale can reduce the installed cost.[10] The tax credits offered for the purchase of this technology could increase sales somewhat; however, the cost—including the tax credit—is still almost double the cost of a traditional gas furnace/central air conditioner system. With energy prices expected to remain stable in real terms over time, it is unlikely that significant increases in market penetration would occur without substantial subsidies or technological breakthroughs leading to large price reductions.

The only generating technology included in the CCTI tax incentive proposal for energy-efficient building equipment is the fuel cell. Currently, units sized for residential applications are in the prototype stage, with a projected commercialization date of 2001-2002. There is only one manufacturer of fuel cells for commercial-sized units. The current cost for a commercial-sized fuel cell is about $3,000 per kilowatt of capacity; the CCTI tax credit would reduce the cost to $2,500 per kilowatt.[11] As an example, assume that a commercial business purchases a fuel cell system, the tax credit is taken and the cost of the fuel cell is financed at 9 percent interest for 7 years. Including the fuel savings that would result from using the heat produced by the fuel cell to satisfy the company's hot water needs in place of a natural-gas-fired water heater, the fuel cell could provide electricity for around 20 to 21 cents per kilowatthour, depending on regional natural gas prices. That cost is about three times the average U.S. commercial electricity price. Thus, a much larger incentive or a dramatic drop in fuel cell costs in the next few years would be required to spur adoption of this technology.[12]

---

[10]Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Reference Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998).

[11]Fuel cell costs from Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Advanced Adoption Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998).

[12]Assumed financing terms also include a 20-percent down payment. Natural gas and electricity prices for this example are 1998 prices from Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).

Results

The analysis results indicate that the CCTI tax incentive proposal for energy-efficient building equipment could reduce projected carbon emissions by 0.85 million metric tons and buildings energy use by 23.9 trillion British thermal units (Btu) in 2005—0.1 percent of delivered energy. Table 3 compares the results for the reference and CCTI analysis cases.

Table 3. Results of the CCTI Tax Incentive for Energy-Efficient Building Equipment

Variable	1997	2005 Reference Case	2005 CCTI Case	2010 Reference Case	2010 CCTI Case
Delivered Energy Use (Trillion Btu)	18,551	19,899	19,875	20,783	20,766
Carbon Emissions Attributed (Million Metric Tons)	522.2	582.5	581.2	613.6	612.8
Energy Bill Savings (Million 1998 Dollars)	—	—	545.9	—	391.2

Sources: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs BLDCCTI.D031999B and BLDCCTI.D033099A.

Given the small increase in the projected market share for the technologies targeted by this tax credit proposal, it follows that a significant portion of the decreased tax revenues could result from tax credits received by consumers who would have purchased the equipment with no additional incentive. For example, sales of all natural gas heat pumps would be eligible for the tax credit, and with sales currently totaling 5,500 units per year, $5.5 million could be claimed by consumers who would have purchased the equipment absent any tax credit. In the years covered by the tax credit (2000-2003), the analysis indicates that a total of 36,444 natural gas heat pumps would be purchased in the reference case,[13] and that an additional 25,119 units would be purchased because of the tax credit in the CCTI case. In the CCTI case, the Treasury would incur a total reduction of $61.6 million in projected tax revenues related to purchases of natural gas heat pumps. Of the $61.6 million, 60 percent of the tax credits paid would go to unintended beneficiaries.

[13]Reference case results based on assumptions used for the *Annual Energy Outlook 1999* (*AEO99*). *AEO99* and the assumptions for *AEO99* are available on the EIA web site at www.eia.doe.gov.

Tax Credits for Energy-Efficient New Homes

The following CCTI tax credits for energy-efficient new homes are proposed:

- In calendar years 2000 and 2001, a credit of $1,000 for new homes that are at least 30 percent more efficient than the International Energy Conservation Code (IECC) (same as EnergyStar Home)
- In calendar years 2000 through 2002, a tax credit of $1,500 for new homes that are at least 40 percent more efficient than the IECC
- In calendar years 2000 through 2004, a tax credit of $2,000 for new homes that are at least 50 percent more efficient than the IECC.

The IECC is a recent update to the more commonly referenced Model Energy Code (MEC), most recently issued in 1995. Given the similarities between the two codes and data and software availability already established for MEC95, MEC95 was used as the basis for qualifying for the tax credits. Because there is some overlap between the equipment eligible for tax credits under the building equipment tax credits and the eligibility requirements for the CCTI credit, only one of the credits can be claimed for a given structure.[14] It is not clear how the energy savings would be certified to assure that the requirements of the tax credit were met.

Given the intricate interactions between building shell measures, equipment measures, building orientation and shading, and equipment sizing, it is difficult for any estimate to incorporate all the potential effects included in designing and building a home. The NEMS residential model is not a building simulation model and therefore cannot handle all the different aspects and interactions of building systems. In order to give some perspective on the magnitude and potential impacts that this tax incentive might have, an offline analysis was completed using a building simulation model (PEAR),[15] the MECcheck software,[16] and a cash flow/payback model. When the three models are used in concert, energy savings, code compliance, and investment information can be determined. Although the models estimate energy savings and code compliance, they do not address all issues associated with the energy efficiency aspects of new home construction. The software used for this analysis, although possibly not the state of the art, was readily available, and analysts were familiar with its use.

Even with the use of very detailed building simulation models, there are several limitations of note regarding this analysis. The MECcheck and PEAR programs do not include a number of options that may affect the costs of meeting the qualifications for the tax incentives. The software does not allow for orientation properties, which allow builders

---

[14]Personal communication from John McClelland, Office of Tax Analysis, Department of the Treasury, March 8, 1999.
[15]U.S. Department of Energy, *Program for Energy Analysis of Residences (PEAR)*, DOE/SF/00098-H3 (Washington, DC, June 1989).
[16]U.S. Department of Energy, Office of Codes and Standards, *MECcheck, Version 2.05* (Washington, DC, February 1998).

to minimize sun exposure in the summer and maximize it in the winter. There is no credit for downsizing the heating and cooling equipment, which allows builders to install smaller, less costly units when a tighter building envelope is in place. There is no accounting for more efficient ventilation systems (e.g., tighter duct work), and only conventional building materials are considered. In addition, there is no unique solution for achieving an energy savings target. To the extent that some of these options can be and are used to meet the CCTI efficiency level requirements, their omission in this analysis may cause higher estimated costs of meeting the program's requirements than if the options were included.

As of the end of 1998, only 16 States had adopted MEC95 or better building codes.[17] Implementation and enforcement of the code are difficult, and construction often is not compliant. Building codes in other States, if they exist, generally are set on a county-specific basis, making estimates of an "average new home" building shell difficult. A somewhat different approach to increase the building of energy-efficient homes is to offer the tax credit to the homebuilder, as opposed to the homeowner. If the credit were offered to the builder, more energy-efficient homes would be made available to prospective buyers, because the builders would receive an incentive to construct more energy-efficient homes. Currently, builders can recoup only the incremental cost of improving energy efficiency in the sales price of the home, because they do not receive the benefits of lower energy bills. To address this issue, Rep. William Thomas (R-CA) is preparing to introduce the Energy Efficient Affordable Home Act of 1999, which would enable the builders of energy-efficient homes to receive the $2000 tax credit.[18] The CCTI tax credit would be available to homeowners only.

For this analysis, two prototype houses were used as typical for two climate regions: north and south. Tables 4 and 5 detail the characteristics and cost of efficiency measures for each prototype and tax credit level. It is assumed that each percentage level specified in the tax credit proposal relates to energy savings relative to the MEC95 code for heating and cooling only. It is further assumed that the most efficient equipment is installed as a means to meet the credit, because it is generally the cheapest option per Btu saved.

[17] Building Standards and Guidelines Program (BSGP), *Setting the Standard*, Volume 7, Issue 2 (1998).
[18] Alliance to Save Energy, "e-FFICIENCY NEWS" (March 1999).

Table 4. South Region Building Code Characteristics[a]

Characteristic	MEC95 Compliant		MEC95 + 30 %		MEC95 + 40 %		MEC95 + 50 %	
	Efficiency	Cost[b]	Efficiency	Cost	Efficiency	Cost	Efficiency	Cost
Heat Pump	10.0/6.8	4,100	15.5/9.4	5,500	15.5/9.4	5,500	15.5/9.4	5,500
Roof Insulation	R-20	1,116	R-27	1,382	R-27	1,382	R-50	2,413
Wall Insulation	R-11	706	R-11	706	R-13	826	R-15	974
Windows	U-.48	924	U-.48	924	U-.48	924	U-.29	2,200
Slab Insulation	None	0	None	0	R-5.2	564	R-5.4	1,486
Air Infiltration	0.63	157	0.63	157	0.63	157	0.63	157
Total Cost		7,004		8,670		9,353		12,730
Incremental Cost		—		1,666		2,230		5,726

[a]Columbia, SC, 1,800 square feet, built on slab.
[b]All costs given in 1998 dollars.
Sources: Cost data from Ernest Orlando Lawrence Berkeley National Laboratory, *Energy Data Sourcebook for the U.S. Residential Sector* (September 1997), and Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Reference Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998).

Table 5. North Region Building Code Characteristics[a]

Characteristic	MEC95 Compliant		MEC95 + 30 %		MEC95 + 40 %		MEC95 + 50 %	
	Efficiency	Cost[b]	Efficiency	Cost	Efficiency	Cost	Efficiency	Cost
Gas Furnace/CAC	78/10.0	3,850	95/16.0	5,450	95/18.0	565	095/18.0	5,650
Roof Insulation	R-31	1,011	R-60	1,788	R-60	1,788	R-60	1,788
Wall Insulation	R-15	1,510	R-27	4,035	R-27	4,035	R-27	4,035
Windows	U-.48	1,319	U-.48	1,319	U-.30	2,195	U-.25	3,793
Floor Insulation	R-15	722	R-15	722	R-15	722	R-21	914
Air Infiltration	0.56	333	0.56	333	0.56	333	0.40	713
Total Cost		8,745		13,648		14,723		16,894
Incremental Cost		—		4,902		5,978		8,148

[a]Chicago, IL, 2,240 square feet, two-story, unheated basement.
[b]All costs given in 1998 dollars.
Sources: Cost data from Ernest Orlando Lawrence Berkeley National Laboratory, *Energy Data Sourcebook for the U.S. Residential Sector* (September 1997), and Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Reference Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998).

Methodology and Results

MECcheck was used to establish the characteristics of a MEC95 compliant home, which were then input into PEAR, a building simulation model developed by the U.S. Department of Energy, to establish MEC95 compliant energy consumption for heating and cooling. The characteristics were then changed to achieve the levels of energy consumption specified in the tax credit proposal. The characteristics shown in Tables 4 and 5 are the results of this process. The costs associated with the efficiency improvements were then mapped to each particular characteristic. As noted above, the solutions given in the tables above are not necessarily unique, nor are they necessarily the least-cost options for obtaining the goal of the tax credit proposal. Furthermore, there is considerable uncertainty in the estimates of the costs of meeting the CCTI efficiency requirements. It is possible that, for some specific locations, costs could be much lower than portrayed here.

To determine the attractiveness of each investment, a spreadsheet model was developed using a cash flow and payback analysis as the means to evaluate the investment. The following assumptions were used in the analysis:

- Homes receiving the tax credit were assumed to be mortgaged at 8 percent for 30 years, with a 10-percent down payment. Thus, if the incremental costs of the energy-efficient home were $2,500, an up-front cost of $250 would occur in the down payment, and mortgage payments would increase by $200 per year.

- The penetration of energy-efficient homes was assumed to be a function of the number of years it would take to achieve a positive cumulative cash flow given the estimated costs and savings and assumed mortgage provisions. The concept of number of years to positive cash flow is similar to, but distinct from, the commonly computed simple payback period.

- In the reference case, EnergyStar homes are built at an increasing rate, with the starting point closely tied to recent results from the program.[19] For the years 2000 and 2001, during which a $1,000 tax credit applies, it was assumed that EnergyStar homes would receive this credit. New homes achieving the 40- and 50-percent energy savings levels were assumed to reduce the baseline of EnergyStar homes, which would not be eligible for the tax credits, by 50 percent after 2001. It was assumed that 50 percent of the new homes built in the reference case would be upgraded to receive the tax credit in the CCTI case. Although this is only an assumption, the incremental savings for upgrades to shell efficiency beyond the 30 percent level generally offer rapid returns with the tax credits in place, and some conversions should be expected.

- In the first 3 years of the program, only homes achieving 30- and 40-percent savings over MEC95 would be built. In the last 2 years of the program, homes achieving 50-percent savings over MEC95 would be built. This assumption represents an increase in the efficiency of homes built as the program matures.

The results are as follows:

[19]The U.S. Environmental Protection Agency web site describes the EnergyStar Homes program, including results for the past 12 months. See web site http://yosemite.epa.gov/appd/eshomes/eshomes.nsf.

- Approximately 222,000 additional energy-efficient homes would be built in the CCTI case during the 2000-2004 period. A total of just under 300,000 homes would receive tax credits averaging nearly $1,800. The total reduction in projected tax revenues would approach $540 million.

- Given the length of time that buildings remain in the housing stock, the benefits of energy and carbon savings would continue for 50 years or more, although these long-term savings are not illustrated here.

- Energy savings for electricity and natural gas and total reductions in carbon emissions would be as shown in Table 6.

Table 6. Projected Energy Savings and Carbon Emissions Reductions in the CCTI Analysis Case for Energy-Efficient New Homes

Projection	1997 Total	2005 Savings	2010 Savings
Delivered Energy (Trillion Btu)	10,921	2.76	2.76
Energy Bill (Million 1998 Dollars)	139,898	34.7	34.7
Carbon Emissions (Million Metric Tons)	285.6	0.1	0.1

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Tax Credits for Rooftop Solar Equipment

The CCTI tax incentive for rooftop solar equipment is aimed at encouraging individuals and businesses to adopt systems that provide heat and electricity without producing greenhouse gases. The credit, equal to 15 percent of the investment cost, applies to rooftop photovoltaic (PV) systems and solar water heating systems located on or adjacent to a building and used exclusively for purposes other than heating swimming pools. Solar water heating systems placed in service during the 5-year period from 2000 through 2004 are eligible up to a maximum credit of $1,000. Rooftop PV systems placed in service during the 7-year period from 2000 through 2006 are eligible for the 15-percent tax credit up to a maximum of $2,000.

Currently, a 10-percent business energy tax credit (BETC) is provided to private businesses for qualifying equipment that uses solar energy to generate electricity, to heat or cool, to provide hot water for use in a structure, or to provide solar process heat. The allowable tax credit for any one year is limited to $25,000 plus 25 percent of remaining taxes after the credit is taken. Credits not allowable in one year may be taken in other tax years. Equipment that uses both solar and non-solar energy must not use more than 25 percent of its total annual energy input from non-solar sources to qualify. Passive solar systems and those owned by public utilities are not eligible. Thus, commercial taxpayers would have to choose between the present tax credit and the proposed CCTI credit for each qualifying investment. For systems that qualify for both credits, only small systems would benefit more from the 15-percent CCTI proposal because of the $1,000 and $2,000 caps. The solar technology costs and tax credits used in the analysis of the proposed CCTI tax credit for rooftop solar systems are shown in Table 7.

Table 7. Cost Data for CCTI Solar Technologies

Technology	Installed Cost[a]	Applicable Tax Credit
Solar Thermal Water Heater . .	$199 per thousand Btu per hour of capacity	BETC: $20 per thousand Btu per hour CCTI: $30 per thousand Btu per hour of capacity, maximum $1,000
Photovoltaic Rooftop System (Current Cost)	$6,944 per kilowatt of capacity	BETC: $694 per kilowatt of capacity
Photovoltaic Rooftop System (Projected Cost, 2000-2006) . .	$6,169 per kilowatt of capacity	BETC: $617 per kilowatt CCTI: $925 per kilowatt of capacity, maximum $2,000

[a]System costs could vary depending on climate, collector quality and type of system.
Sources: Solar thermal costs are based on Energy Information Administration, *Technology Forecast Updates: Residential and Commercial Building Technologies—Reference Case*, prepared by Arthur D. Little, Inc. (Washington, DC, September 1998). PV costs are based on U.S. Department of Energy, Office of Building Technologies, *Building Integrated Photovoltaics (BIPV), Analysis and U.S. Market Potential* (Washington, DC, February 1995). Tax credits from Department of the Treasury, "General Explanations of the Administration's Revenue Proposals" (February 1999). Costs are given in 1998 real dollars. The tax credit is assumed to apply to the purchase price, including installation costs.

Tax credits for solar hot water heaters have been used in the past to create a niche market for solar water heaters. In the early 1980s, medium-temperature (the type used for water heaters) solar thermal collector shipments peaked at just under 12 million square feet (enough for roughly 300,000 units) per year. After the Federal 40-percent residential and 15-percent business energy tax credits expired at the end of 1985, shipments fell to less than 1 million square feet per year, and have never recovered.[20] The business energy tax credit was reinstated at 15 percent for 1986 and phased down to 10 percent by 1992, with the Energy Policy Act of 1992 (EPACT) providing a permanent extension of the BETC.

The credit reinstatement and increasing oil prices after 1986 did not seem to create a rebound of the solar industry. Today, most (85 percent) solar collector shipments are used for heating swimming pool water, which is excluded from the tax credit. In 1997, EIA estimates that roughly 460,000 households (0.5 percent) used solar water heaters to provide some of the energy required to heat the annual load of hot water.[21] Currently, about 9 percent of solar thermal collector shipments are destined for the commercial sector. Only 0.5 percent of all solar thermal collector shipments purchased by the commercial sector are for uses other than heating swimming pools, even with the existing energy tax credit available.

[20]Energy Information Administration, *Solar Collector Manufacturing Activity 1993*, DOE/EIA-017(93) (Washington, DC, August 1994).
[21]Energy Information Administration, *Housing Characteristics, 1997*, DOE/EIA-0314(97), available on the EIA web site at www.eia.doe.gov/emeu.

Residential rooftop PV systems are uncommon. Some are used for remote power generation, where connection to the electrical grid would be prohibitively expensive. PV systems are also rare in the commercial sector, used primarily for power generation and communications.[22] The 10-percent BETC is generally not enough to make PV systems economically attractive to the commercial sector, where purchased electricity is readily available. There are Federal, State, and local programs and incentives to encourage use of solar technologies. Locally, under the PV Pioneer I program, the Sacramento Municipal Utility District (SMUD) has created a small market for solar photovoltaics by installing the equipment on residential rooftops for $4.00 per month for 10 years. The homeowner is, however, obligated to pay SMUD's current rate for electricity. Since 1993, more than 450 homes have participated in the program. SMUD has recently launched PV Pioneer II, which allows homeowners to purchase their own PV systems and participate in net metering, generating their own electricity at no cost and paying for the electricity needed from the electrical grid. Any excess electricity generated from the PV system is sold back to the grid for future credit.[23] With energy prices expected to remain stable in real terms, it is likely that substantial subsidization or technological breakthroughs leading to large price reductions would be required to foster increased penetration of residential PV systems.

The reference case for this analysis includes the current 10-percent BETC for both solar thermal water heaters and PV systems. Commitments to DOE's Million Solar Roofs (MSR) program (see Chapter 3) are also included in the reference case. The analysis does not include consideration of any State or local incentives.

Results

No change from reference case results was seen when the CCTI tax incentive for rooftop solar equipment was included in the NEMS residential and commercial modules. It should be noted that many of the units completed under the MSR program could be eligible for the solar tax credit. Approximately 400,000 units are planned to be constructed under the program from 2000 through 2006, the period of the solar tax incentives.[24] Any such units receiving the tax credits during this interval probably would be unintended beneficiaries, because the MSR program pre-dates the CCTI tax incentives. The proposed tax credit is modest compared to the 40-percent residential credit available in the past. Niche markets with local incentives in place and electricity rates much higher than the national average could create a situation in which the CCTI tax incentive would make solar technologies economically attractive; however, the proposed incentive is much less than would be required to spur the growth in sales needed to lower production costs significantly and prompt even greater adoption of the technology.

[22]Energy Information Administration, *Renewable Energy Annual 1996*, DOE/EIA-0603(96) (Washington DC, March 1997), and *Renewable Energy Annual 1998*, DOE/EIA-0603(98) (Washington DC, December 1998).
[23]For more information on SMUD's PV Pioneer programs, see web site www.smud.org/home/pv_pioneer/index.html.
[24]Interpolation of estimated units from web site www.eren.doe.gov/millionroofs/benchmark.html.

Industry

Background

The CCTI proposal includes a new investment tax credit for the installation of combined heat and power systems (CHP) that meet specified energy efficiency targets. The reduction in capital cost resulting from the tax credit is intended to induce additional investments in CHP. For the analysis of this proposal, the NEMS industrial demand module was modified to estimate the likely incremental impacts of the CHP tax credit on energy consumption and carbon emissions. Other potential benefits of the CHP tax credit (such as reduction of other pollutants) were not considered.

This analysis did not address district heating systems. The NEMS commercial model incorporates consumption of district energy services, but central district heating plants are not modeled explicitly in NEMS. To the extent that district heating plants are owned by governmental entities, however, an investment tax credit is likely to have little impact on expanding district heating.

The analysis did not include the potential effects of removing institutional barriers to CHP and merchant power plants. Elimination or reduction of barriers due to, for example, standby rates, exit fees, establishing uniform interconnection standards, or reform of environmental permitting policies could lead to a substantially larger CHP increase than is likely with the CHP investment tax credit alone.[25] One analysis has concluded that institutional barriers to CHP systems represent a significant impediment to greater deployment of the technology.[26] The study estimated that addressing four types of institutional barriers could lead to an additional 50 gigawatts of CHP by 2010. The specific measures advocated were the following: expedited permitting for CHP systems; output-based air pollution regulations; removal of a variety of "utility-driven" barriers; and establishing a standard depreciation period of 7 years for all new CHP systems.

The analysis specifically did not include any existing, ongoing programs, such as Industries of the Future, the Advanced Turbine System Program, research and development programs, or voluntary programs. The likely energy impacts of those programs are regularly assessed by the Department of Energy and are not further reviewed here.

---

[25]While the Administration has not presented a detailed discussion of their intentions in this area, a laundry list of possibilities can be found in Thomas R. Kasten, *Turning Off the Heat* (New York, NY: Prometheus Books, 1998).

[26]American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the United States* (Washington, DC, August 1998).

Tax Credit for Combined Heat and Power

The CCTI proposal would implement an 8-percent investment tax credit for qualified CHP systems. A qualified system must be placed in service between 2000 and 2002 and must be larger than 50 kilowatts. The proposed legislation would require that systems which currently have a tax life of 7 years or less adopt a tax life for depreciation purposes of 15 years. This requirement would reduce the effective tax credit to about 4 percent and, presumably, would eliminate participation by biomass-fired cogeneration from the pulp and paper industry.[27] Additional conditions, which vary with system size, must also be met (Table 8).

Table 8. CCTI Requirements for Qualifying Combined Heat and Power Systems

System Size[a]	Minimum Electric or Mechanical Power (Percent)	Minimum Useful Thermal Output (Percent)	Minimum Overall System Efficiency (Percent)
Less than 50 Megawatts	20	20	60
Greater than 50 Megawatts	20	20	70

[a]The minimum size requirement is 67 horsepower for mechanical systems. The 50-megawatt system size corresponds to 67,000 horsepower.
Source: U.S. Department of the Treasury, *General Explanation of the Administration's Revenue Proposals* (Washington, DC, February 1999), pp. 45-46.

The efficiency requirements ensure that qualifying systems genuinely produce both heat and power in substantial amounts. In contrast, cogeneration systems qualifying under the Public Utility Regulatory Policies Act of 1978 (PURPA) were only required to produce thermal output equal to 5 percent of useful energy output. As a result, much of the PURPA-induced cogeneration capacity added since 1978 was designed with minimal thermal output and relatively low overall efficiency. Such "nontraditional" cogeneration capacity, which represents approximately one-half the total CHP in operation, generally provides little efficiency improvement over comparable systems (combined-cycle plants) installed by electric utilities.

The proposed tax credit for CHP systems is expected to have its primary impact on traditional cogeneration in the industrial sector, which is the focus of this analysis. There may be some impact on nontraditional or merchant plant facilities, but the CCTI CHP system efficiency standard of 0.7 would exclude many plants that are designed to maximize electrical output rather than total system efficiency. Because total system efficiency falls as the ratio of electric output to useful thermal output increases, nontraditional CHP plants do not generally meet the system efficiency requirement to qualify for the ITC. Traditional industrial cogeneration accounts for about 40 percent of total cogeneration capacity (Table 9). The remainder is in refining, oil and gas production, the commercial sector, and the nontraditional category.

[27]This analysis did not address the likelihood of the successful demonstration and widespread adoption of black liquor gasification combined-cycle technologies, which could lead to such a large increase in self-generation that the industry would become a net seller of electricity after 2010.

Table 9. Components of Cogeneration Capacity in the Reference Case, 1999 and 2002
(Gigawatts)

Component	1999	2002
Traditional Industrial	20.8	21.7
Refining	2.9	2.9
Enhanced Oil Recovery	2.3	2.3
Commercial	0.6	0.6
Nontraditional	26.2	26.2
Total	**52.7**	**53.6**

Source: Energy Information Administration, National Energy Modeling System, run AEO99R.D033099A.

Methodology

The effects of the proposed CHP tax credit were assessed by estimating the relationship between CHP project economics and market penetration, using a new methodology developed and implemented in the NEMS industrial module. The approach estimates industrial CHP market penetration as a function of steam requirements by industry, existing CHP, CHP system costs and performance, and investment payback acceptance rates to provide a quantitative framework for evaluating the effect of policies to improve CHP economics, as well as the removal of barriers to CHP (such as high standby electricity rates imposed on CHP facilities by some electric utilities). The analysis was limited to an assessment of gas turbine CHP systems, which are well-suited for a wide range of applications and represent the predominant technology used for new CHP installations.[28]

The methodology was designed to determine the technical potential for CHP, evaluate its economic potential, and estimate annual capacity additions. The technical potential for CHP exists at facilities with significant thermal energy uses, generally in the form of process steam. Because steam is relatively expensive to transport, industrial CHP systems are typically sited at the facility where the thermal energy will be used. While the electric power from CHP is most often applied to the facility's own uses, it can also be supplied to the grid. Thus, the thermal needs of a facility, not necessarily the electric power needs, determine the technical potential for CHP.

The assessment of the potential for new CHP begins with an examination of the thermal requirements of industry and the amount of CHP, or cogeneration, already in place. Many of the best sites for cogeneration in the industrial sector currently are being used, and 35 to 40 percent of the steam used in the industrial sector is already produced through cogeneration. However, additional cogeneration could meet some portion of the remainder of the existing steam requirements, as well as any growth in steam requirements as industry expands. The incremental technical

[28]Other analyses of CHP potential have assumed that most CHP additions will be gas-fired. See, for example, American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the United States* (Washington, DC, August 1998), p. 28.

potential is estimated to be about 100 gigawatts, almost 40 percent of which arises in industries with relatively small thermal requirements, where the economic desirability of CHP systems is sharply reduced.

To estimate CHP growth, the potential thermal (steam) capacity for new cogeneration is estimated under the assumption that cogeneration systems would be sized to meet average hourly steam loads. In addition, the ratio of power to steam produced by typical cogeneration systems is used to estimate the corresponding electric generating capacity. Because the characteristics of cogeneration systems vary with size, the analysis accounts for several ranges of thermal output that candidate CHP systems would supply. The thermal requirements of each industry are divided among these thermal ranges, based on the size distribution of boiler capacity. For each thermal load range, one of five candidate CHP systems is selected as a prototype by matching the average hourly thermal requirement within the range.

The five prototype cogeneration systems are assumed to have the characteristics shown in Table 10, which were developed from information supplied by manufacturers, as well as several industry studies.[29] While the technical specifications are often available, the typical total cost of installed systems is not available. Total system installed costs are about twice those for gas turbine generators. As summarized in one study: "Thus the installed cost of a gas turbine with an HRSG can be estimated from the FOB price by multiplying this price by a factor of the order of 1.8-2.3."[30]

Table 10. Characteristics of Candidate Cogeneration Systems

Characteristics	Prototype System				
	1	2	3	4	5
Electricity Capacity (Kilowatts)	1,000	2,500	5,000	10,000	40,000
Total System Cost (1997 Dollars per Kilowatt)	1,600	1,400	1,200	1,000	950
Capacity Factor	0.8	0.8	0.8	0.8	0.8
Overall Efficiency	0.7	0.7	0.7	0.75	0.8
Heat Rate (Btu per Kilowatthour)	14,217	13,132	11,263	10,515	9,749
Net Heat Rate (Btu per Kilowatthour)	6,042	5,907	5,673	4,922	4,265
Steam Output (Million Btu per Hour)	6.5	14.5	22.4	44.7	175.5
Power-Steam Ratio (Btu Electric per Btu Steam)	0.52	0.59	0.76	0.76	0.78

Source: Energy Information Administration estimates based on information from Caterpillar, Allison Gas Turbines, and Centre for the Analysis and Dissemination of Energy Technology (CADDET): *Gas-Turbine-Based CHP in Industry* (1993) and *Small-Scale Cogeneration* (1995).

[29]The economic evaluation methodology draws heavily from two recent books on CHP from the Centre for the Analysis and Dissemination of Energy Technology (CADDET): *Gas-Turbine-Based CHP in Industry* (1993) and *Small-Scale Cogeneration* (1995). Some characteristics, such as heat rates of gas turbines, are based on data provided from Solar Turbines (owned by Caterpillar) and Allison Gas Turbines.

[30]Centre for the Analysis and Dissemination of Energy Technology (CADDET), *Gas-Turbine-Based CHP in Industry* (1993), p. 45.

A prototype system for each thermal size range is evaluated as a discretionary investment opportunity, based on regional prices of natural gas and electricity. The evaluation estimates the investment payback period for a CHP investment. The payback estimates, together with the system size characteristics, are used to estimate market penetration.

The total technical potential for CHP is calculated assuming all prototype systems are installed, irrespective of economics. The economic potential, or the fraction of technical CHP potential that would be realized on the basis of relative economic attractiveness, is estimated from the payback periods. To estimate economic potential, an assumed quantitative relationship was formulated to describe the general notion that the shorter the payback period is, the greater is the likelihood that an investment will be undertaken. This assumed relationship, the "payback acceptance curve," quantifies the fraction of firms that would accept a given payback period. A study prepared for the U.S. Department of Energy indicates that 21 percent of cogeneration projects with a 3.3-year payback period were implemented.[31] Consequently, the analysis incorporates a payback acceptance curve that reflects the hypothesis that the average payback period for CHP additions would be 2.5 years or less. However, the acceptance curve adopted also assumes that about 25 percent of sites would accept a payback period of 5 to 10 years. The values assumed for the payback acceptance curve for traditional industrial cogeneration used in this analysis are shown in Table 11.

[31] U.S. Department of Energy, *Analysis of Energy-Efficiency Investment Decisions by Small and Medium-Sized Manufacturers*, DOE/PO-0043 (Washington, DC, March 1996), Table 4-2. Interestingly, the same study reported that more than 40 percent of energy conservation projects with an immediate payback were not undertaken.

Table 11. Assumed Values for the CHP Investment Payback Acceptance Curve

Payback Period for CHP Investment (Years)	Percentage of Firms Willing to Invest
0	100.0
1	88.5
2	64.0
3	39.5
4	20.5
5	9.8
6	5.5
7	3.8
8	2.5
9	1.6
10	0.9
11	0.3
12	0.0

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

For this analysis, the market penetration of industrial CHP over the 2000 to 2002 period was estimated with and without the proposed 8-percent investment tax credit. The primary effect of the credit is to reduce the capital cost of the cogeneration system, and thus the investment payback period, by 8 percent,[32] thereby reducing a project's payback period and increasing the likelihood that the project will be undertaken. The result is higher overall economic potential and higher annual additions, as a greater share of candidate sites find CHP sufficiently attractive to invest in it.

Although a small amount of refinery CHP is projected to be induced by the tax credit, the impact will be significantly attenuated by other capital demands that are being placed on the refining industry. Over the next few years, the industry must make substantial capital investments to meet fuel quality and plant emissions requirements of the Clean Air Act Amendments and upcoming regulations.[33] The most costly capital spending requirement for the refinery industry is likely to be a restriction on the allowable sulfur content of all gasoline. In early 1999, the EPA

[32]For CHP systems with a 7-year tax life, the effect of the tax credit is reduced by increasing the depreciation period that can be used for tax purposes to 15 years.

[33]Investments should be nearing completion that will allow refineries to produce reformulated gasoline to meet reduced emissions requirements in January 2000. Capital investments may also be required to meet new standards that will reduce emissions of hazardous air pollutants (HAPS) from certain refinery units by 2002. In addition to these Federal requirements, separate gasoline requirements being adopted by States may require further investments. For instance, the State of Georgia has a requirement that the Atlanta area must use gasoline with reduced volatility and sulfur content. Upcoming rulemakings that would reduce the allowable sulfur content of gasoline and diesel are expected to require sizable investments. Further expenditures may also be required if concerns about methyl tertiary butyl ether (MTBE) contaminating water supplies lead to restrictions on its use as an oxygenate in gasoline.

is expected to propose a reduction in the average allowable sulfur content in gasoline to 30 parts per million (ppm)—down from the current average of 340 ppm. EPA estimates that low-sulfur gasoline will cost 1 to 3 cents more per gallon. Because gasoline sulfur and automotive emissions are linked, the proposal will be issued in conjunction with the new "Tier 2" vehicle exhaust emissions standards, which would take effect between 2004 and 2007. Also expected in 1999 is a preliminary notice of proposed rulemaking that would reduce the sulfur content of diesel fuel to accommodate reductions in emissions of NO_x and particulates.

The oil and gas production industry is also unlikely to expand the use of CHP for enhanced oil recovery (EOR) within the 2000-2002 period. Current low crude oil prices would not support an increase in steam production from EOR development. About 20 percent of EOR capacity has been idled, and that capacity would be returned to service before new plants or additions were built. In this economic environment, an 8-percent tax credit for investment in CHP equipment is not likely to induce additional CHP for EOR steam production.

Results

In the reference case for this analysis,[34] 873 megawatts of new cogeneration capacity are projected to be added between 2000 and 2002 (Table 12). In the CCTI analysis case, an additional 190 megawatts of new CHP capacity is projected to be installed during the 3-year period.[35] However, all the capacity projected to be added in the 2000-2002 period—1,064 megawatts—would qualify for the credit. If the average system capital cost is $1000 per kilowatt, the total reduction in projected tax revenues would be $85 million. If capacity additions that would have occurred in the absence of the tax credit in 1999 or 2003 were moved to the 2000-2002 window, total additions qualifying for the ITC would be 1,567 megawatts, bringing the total reduction in tax revenues to $125 million.[36]

---

[34]The reference case for this analysis differs slightly from the reference case used for the *Annual Energy Outlook 1999*. The difference reflects the revised methodology used to project cogeneration.

[35]Note that this estimate does not include the "bunching effect" that could arise if projects that would have been undertaken without the credit in 1999 or 2003 were moved to the 2000-2002 window to take advantage of the tax credit.

[36]By comparison, in "President Clinton's FY 2000 Climate Change Budget," p. 2, the Administration estimates that the credit will reduce tax revenue by $300 million. Assuming that the installed cost for CHP systems averages $1000 per kilowatt, this implies that the Administration anticipates that qualifying CHP additions during the 3-year period will be 3,750 megawatts. It is not known what portion of the Administration's tax expenditure estimate is due to unintended beneficiaries.

Table 12. Projected Effects of the CCTI Tax Credit on Traditional Industrial Cogeneration, 2000-2002

Cumulative Capacity Additions in the Reference Case (Megawatts)	873
Incremental Capacity Additions in the CCTI Analysis Case (Megawatts)	190
Cumulative Capacity Additions in the CCTI Analysis Case (Megawatts)[a]	1,064 to 1,567
Reduction in Projected Tax Revenues (Million Dollars)	85 to 125
Net Carbon Reduction, 2002 (Million Metric Tons)	0.150

[a]The range results from the possibility that currently planned additions will be moved from 1999 or 2003 to take advantage of the CCTI tax credit.
Source: Energy Information Administration, National Energy Modeling System, runs AEO99R.D033099A and CCTITAX.D033099A.

The increased penetration of CHP is likely to reduce carbon emissions overall. Although an increase in CHP would increase total industrial fuel consumption, the resulting reduction in electricity purchases would displace fuel used by central power stations. With CHP, the incremental amount of fuel used to produce a unit of electricity is generally lower than for central power stations. The net carbon emissions reduction can be calculated from the difference between the average electricity carbon factor (66 million metric tons per quadrillion Btu of electricity produced) and the natural gas carbon factor (14.5 million metric tons per quadrillion Btu of natural gas consumed). Multiplying the "net carbon factor" by the increase in cogenerated electricity yields an estimate of the carbon reduction. Accordingly, the CCTI tax incentive has the potential to reduce carbon emissions by 0.15 million metric tons per year—a relatively small fraction of the approximately 512 million metric tons of industrial carbon emissions projected for 2002.

The results presented above could be altered significantly if a variety of institutional barriers that impede CHP projects could be reduced. For example, EPA has proposed that CHP plants be given set-aside allowances in their proposed NO_x trading program.[37] One result of reduced institutional impediments could be a greater willingness to invest in CHP projects with longer payback periods, because the required payback period incorporates the potential for unforeseen complications and delays due to existing institutional arrangements as well as the strictly financial aspects of a project. To assess the effects of this possibility, a sensitivity analysis was conducted assuming that a much longer (approximately doubled) payback period would be acceptable. The sensitivity analysis indicates that as much as 645 megawatts of additional new CHP capacity could be induced. In this situation, net carbon reductions of 0.5 million metric tons could occur.

The cost of the CHP tax incentive program could be higher if nontraditional cogenerators (merchant plants) were able to qualify for the credit. Nontraditional cogenerators are facilities built mainly to sell power. Because their production of useful thermal energy is typically small relative to their power output, the total system efficiency of merchant units is below the minimum threshold specified in the CCTI proposal. In NEMS, merchant facilities are

[37]U.S. Environmental Protection Agency, Office of Atmospheric Programs, Office of Air and Radiation, *Guidance on Establishing an Energy Efficiency and Renewable Energy (EE/RE) Set-Aside in the NOx Budget Trading Program* (Washington, DC, March 1999).

treated as simple electricity power plants rather than as cogenerators; however, they could have a more significant impact if some regulatory burdens and uncertainties were reduced. For example, establishing a uniform interconnection standard could lead to more additions of merchant power plant capacity, as well as more traditional cogeneration capacity.

Because the proposed investment tax credit would expire in 2002, no additional induced change is projected after 2002. It is possible, however, that a "momentum" effect could lead to some additional inducement even after the tax credits expire (Table 13).

Table 13. Projected Effects of the CCTI Tax Credit for Combined Heat and Power (CHP) Systems, 2005 and 2010

Projection	1997	2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case
CHP Capacity (Gigawatts)	23.1	25.3	25.5	26.4	26.6
CHP Generation (Billion Kilowatthours)	154.8	165.0	166.4	172.6	174.0
Industrial Carbon Emissions (Million Metric Tons)	482.1	520.2	520.0	546.9	546.7

Note: Carbon emissions for the CCTI case cannot be taken directly from an integrated NEMS run because of the interaction effects.
Source: Energy Information Administration, National Energy Modeling System, runs AEO99R.D033099A and CCTITAX.D033099A.

Finally, the analysis indicates that there could be a very high ratio of unintended beneficiaries for this program. The projected ratio of unintended beneficiaries (capacity that would be added in the absence of the credit) to induced capacity additions is more than 4 to 1. This result is due in part to the short time frame for the proposed credit. Because it takes 18 to 36 months to plan, design, and install new CHP capacity, most of the facilities that would qualify for the credit would have been installed without it. Further, the proposed tax credit would shorten the payback period for investments in new CHP capacity by less than 3 months—a marginal benefit that is unlikely to affect the economic decision for most firms.

Transportation

Tax Credits for Electric, Electric Hybrid, and Fuel Cell Vehicles

Background

Sales of alternative-fuel vehicles (AFVs) and advanced vehicle technology (AVT) vehicles are expected to make up approximately 4 percent of all U.S. light-duty vehicle (LDV) sales in 1998.[38,39] More than 58 percent of those sales are alcohol flexible vehicles, which can run on any combination of alternative fuel and gasoline, and 41 percent are AFVs that use either compressed natural gas (CNG) or liquid petroleum gas (LPG). The remaining 1 percent are electric vehicles.

The electric vehicles currently available (Table 14) average 17 to 30 percent higher fuel efficiency than comparable conventional gasoline vehicles. Whereas conventional gasoline vehicles achieve only about 18 to 28 percent efficiency in combustion, electric vehicle motors have almost no loss in thermal efficiency. On the other hand, approximately 66 percent of the primary energy used to produce electricity is lost in production and transmission.

Table 14. Electric Vehicles Currently Available in U.S. Markets and Announced Dates of New Production Prototypes

Manufacturer	Currently Available Electric Vehicles	Production Prototype Availability Dates	
		Hybrid Electric Vehicles	Fuel Cell Vehicles
Chrysler	Epic minivan	—	Gasoline: 2010 Hydrogen or Methanol: 2004
Ford	Ranger pickup	—	2004
GM	EV1 two seater S-10 pickup	2001	2004
Honda	EV Plus compact	1999	2003
Nissan	Altra minivan	1999	2005
Toyota	RAV 4 sport utility	2000[a]	2003

[a]The Toyota Prius hybrid electric vehicle, already being marketed in Japan, will be available to U.S. buyers in 2000.
Sources: *Electric Vehicle Today* and *Alternative-Fuels Today* (various issues, 1999).

Hybrid electric vehicles are just beginning to enter the marketplace. For example, the Toyota Prius uses a gasoline engine and regenerative braking to restore power to an electric battery that runs the vehicle motor. It has been

[38]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).
[39]AFVs are vehicles that use alternative fuels (other than gasoline or diesel fuel). AVT vehicles use advanced vehicle technologies but consume conventional fuels (examples include gasoline-electric hybrids, diesel-electric hybrids, and gasoline fuel cells). LDVs include all passenger cars, minivans, sport utility vehicles, and pickup trucks.

advertised as having reached 66 miles per gallon (mpg) in the Japanese fuel efficiency test cycle, but in the U.S. Federal test procedure (FTP) cycle it has been rated at only 50 to 55 mpg.

Fuel cell vehicle technology is still in the early stages of development. Only a few test vehicles—buses in the Chicago Transit Authority fleet—have been sold, and some mechanical problems with those have been reported. Fuel cell vehicles have the potential to increase fuel economy relative to conventional gasoline vehicles by some 72 percent with gasoline as a fuel, 84 percent with methanol, and 100 percent with hydrogen.

CCTI Proposals

The CCTI proposes the following tax initiatives for LDVs:

- For qualifying electric and fuel cell vehicles, the current 10-percent tax credit, subject to a $4,000 cap, would be extended at its full level through 2006. The credit currently is scheduled to be phased down beginning in 2002 and eliminated by 2005.

- For qualifying electric hybrid vehicles, graduated tax credits are proposed:

  - $1,000 for each vehicle purchased after December 31, 2002, and before January 1, 2005, that is 33 percent higher in fuel efficiency than a comparable vehicle in its class

  - $2,000 for each vehicle purchased after December 31, 2002, and before January 1, 2007, that is 66 percent higher in fuel efficiency than a comparable vehicle in its class

  - $3,000 for each vehicle purchased after December 31, 2003, and before January 1, 2007, that is twice as high in fuel efficiency as a comparable vehicle in its class

  - $4,000 for each vehicle purchased after December 31, 2003, and before January 1, 2007, that is three times as high in fuel efficiency as a comparable vehicle in its class.

  In order for hybrid vehicles to qualify they must have regenerative braking and an energy storage system that will recover at least 60 percent of the energy used in braking from 70 to 0 mph.

All qualifying vehicles must meet or exceed all emissions requirements for gasoline vehicles.

Analytical Approach

The NEMS AFV/AVT module represents conventional gasoline vehicles (including direct injection gasoline technology and 58 other fuel-saving technologies), diesel turbo direct injection, alcohol (both methanol and ethanol) flexible fueled and dedicated vehicles, gaseous (both CNG and LPG) dedicated and bi-fuel vehicles, electric vehicles, electric hybrid (gasoline and diesel) vehicles, and fuel cell vehicles (methanol, hydrogen, and gasoline reformers). Each AFV/AVT technology is evaluated within each of the 12 EPA size classes for both cars and light trucks. The following consumer purchase criteria were evaluated:[40] (1) vehicle price, (2) cost of driving per mile (fuel price divided by fuel efficiency), (3) vehicle range, (4) top speed, (5) acceleration, (6) multiple fuel capability, (7) maintenance cost, (8) luggage space, and (9) fuel availability.

It was assumed that there would be no new requirements or additional costs for catalysts, engine design changes, or advanced reformulated fuels to meet U.S. Environmental Protection Agency (EPA) vehicle emissions standards. If stricter EPA standards are passed, they could lower the market penetration rates and carbon emissions reductions projected in this analysis.

The following assumptions were made in modeling the CCTI analysis case:

- All electric vehicles and fuel cell vehicles were provided with a $4,000 vehicle price reduction relative to the reference case price through 2006. The date of commercial availability for fuel cell vehicles was changed from 2010 in the reference case to 2006.[41]

- All electric hybrid vehicles were provided with the tax incentives specified in the CCTI proposal, based on the average fuel efficiency of a comparable gasoline vehicle in each EPA size class. Gasoline-electric hybrids were assumed to be commercially available by 2001 and diesel-electric hybrids by 2005 (both the same as in the reference case).

Results and Discussion

The results for the CCTI analysis case show an early increment in sales of electric vehicles—8,700 total sales in 2002, compared with 7,300 in the reference case. By 2010, however, the projected sales are the same in the two cases at about 299,200 units (Table 15). Sales of fuel cell vehicles, which are assumed to be available at the very earliest by

[40]Consumer purchase (market penetration) criteria were based on the U.S. Department of energy's National Alternative-Fuel Vehicle Survey and were implemented in the NEMS AFV/AVT module by EIA's Office of Integrated Analysis and Forecasting in coordination with the U.S. Department of Energy, Office of Transportation Technologies, and Argonne National Laboratory.

[41]According to the Partnership for a New Generation of Vehicles (PNGV) program, the earliest possible availability date for a production prototype fuel cell vehicle would be 2004. Chrysler has announced that a production prototype will be available by 2004. Inherent in the 2006 date is a 2-year period to convert production prototypes to actual production vehicles and to modify production lines and facilities.

2006, are projected to total approximately 700 units in 2006, rising to 4,200 in 2010 and 18,300 in 2020 in the CCTI case. Projected sales of hybrid vehicles—particularly, gasoline-electric hybrids—are significantly higher in both cases than are sales of either electric vehicles or fuel cell vehicles. Hybrids are anticipated to be available in U.S. markets by 2000, and the technology allows for vehicle characteristics that are similar to those of conventional gasoline vehicles—especially the most important consumer purchase criterion, vehicle price (see discussion below).

Table 15. Light-Duty Vehicle Sales, 1997-2010
(Thousands)

Vehicle Type	1997	2002		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI Case
Electric	0.7	7.3	8.7	281.9	283.8	299.2	299.2
Fuel Cell	0.0	0.0	0.0	0.0	0.0	2.6	4.2
Diesel-Electric Hybrid	0.0	2.4	2.4	21.7	23.2	37.3	37.9
Gasoline-Electric Hybrid	0.0	29.0	32.30	198.0	200.4	579.6	593.2
All Light-Duty vehicles	13,618	13,274	13,274	13,836	13,836	14,780	14,780

Source: Energy Information Administration, National Energy Modeling System runs AEO99TRN.D022499B and AEO99TRN.D022499A.

Total AFV/AVT sales in the CCTI case represent less than 4 percent of all LDV sales in 2010 (Table 15). Moreover, most of the projected sales also occur in the reference case. Because the proposed CCTI tax incentives would be in effect only through 2006, no significant additional accumulation of AFV/AVT vehicles is projected, even by 2010. Consequently, projected LDV fuel consumption in the CCTI case does not differ significantly from that in the reference case (Table 16). The difference in 2005, is less than 10.5 trillion Btu, consisting almost entirely of a reduction in gasoline consumption. The difference in 2010 is only 42.3 trillion Btu, and in 2020 it is just 10.5 trillion Btu. As a result, the reduction in projected carbon emissions from transportation energy use in the CCTI case relative to the reference case is only about 0.2 million metric tons in 2005 and 0.8 million metric tons in 2010—representing just 0.13 percent of total carbon emissions for the transportation sector (Table 17). In 2020, the CCTI case results in a reduction of 2.0 million metric tons of carbon.

Table 16. Light-Duty Vehicle Fuel Consumption, 1997-2010
(Trillion Btu)

Fuel Type	1997	2002		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI Case
Gasoline	13,902.00	15,518.00	15,518.00	16,309.00	16,299.00	17,449.00	17,411.00
Distillate Fuel	7.43	6.93	6.94	12.48	12.62	46.89	46.76
Methanol	1.17	31.35	31.18	51.04	50.65	77.38	75.42
Ethanol	0.53	17.84	17.74	30.10	29.82	51.13	50.43
Compressed Natural Gas	11.91	108.80	108.70	172.90	172.50	234.40	233.40
Liquefied Petroleum Gas	20.97	60.50	60.33	104.50	104.10	154.60	153.80
Electricity	0.26	2.79	3.06	39.94	40.56	83.13	83.40
Hydrogen	0.00	0.00	0.00	0.00	0.00	0.01	0.03
Total	13,945.00	15,745.80	15,745.90	16,719.60	16,709.10	18,096.20	18,053.90

Source: Energy Information Administration, National Energy Modeling System runs AEO99TRN.D022499B and AEO99TRN.D022499A.

Table 17. Transportation Sector Carbon Emissions by Fuel Type, 1997-2010
(Million Metric Tons)

Fuel Type	1997	2002		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI case
Petroleum	461.9	521.8	521.8	552.0	551.8	600.8	600.0
Natural Gas	10.5	12.8	12.8	14.7	14.7	16.7	16.7
Electricity	2.9	3.3	3.3	5.2	5.2	7.6	7.6
Other	0.0	0.5	0.5	0.9	0.9	1.4	1.3
Total	**475.3**	**538.5**	**538.5**	**572.8**	**572.6**	**626.3**	**625.5**

Source: Energy Information Administration, National Energy Modeling System runs AEO99TRN.D022499B and AEO99TRN.D022499A.

Projected AFV/AVT vehicle sales and the corresponding reductions in Federal tax revenues in the CCTI analysis case are shown in Table 18. In 2003, the reduction in tax revenues totals just over $10 million, growing to $15 million in 2005 and $21 million in 2006. The total proposed allocation of Treasury funds for the CCTI tax incentives is $900 million for the years 2000 to 2004, as estimated by the Administration, compared to $840 million in this analysis.

Table 18. Projected Vehicle Sales and Reductions in Projected Tax Revenues in the CCTI Analysis Case by Vehicle Type, 2002-2006

Vehicle Type	2002 Reference Case	2002 CCTI Case	2003 Reference case	2003 CCTI Case	2004 Reference Case	2004 CCTI Case	2005 Reference Case	2005 CCTI Case	2006 Reference Case	2006 CCTI Case
Vehicle Sales (Thousands)										
Electric	7.3	8.6	276.2	278.4	277.9	279.9	281.9	283.8	284.7	286.5
Fuel Cell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7
Gasoline-Electric Hybrid	29.0	32.3	70.3	70.3	122.3	129.8	198.0	200.0	266.6	270.8
Diesel-Electric Hybrid	2.3	2.4	11.9	12.8	16.6	17.7	21.7	23.2	26.5	28.1
Total	**38.6**	**43.3**	**358.4**	**361.5**	**416.8**	**426.4**	**501.6**	**507.0**	**578.0**	**586.1**
Tax Revenue Reductions (Million 1997 Dollars)										
Electric	29.4	34.5	1,105.0	1,113.5	1,111.5	1,119.4	1,127.7	1,135.2	1,138.9	1,146.0
Fuel Cell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	732.0	2,658.0
Gasoline-Electric Hybrid	58.0	64.6	140.6	140.7	244.5	259.6	396.0	400.8	533.3	541.6
Diesel-Electric Hybrid	4.7	4.8	23.8	25.6	33.1	35.5	43.3	46.3	52.9	56.2
Total	**92.0**	**104.0**	**1,269.3**	**1,279.7**	**1,389.1**	**1,414.5**	**1,567.0**	**1,582.3**	**1,725.8**	**1,746.5**

Source: Energy Information Administration, National Energy Modeling System, Reference case: AEO99TRN.D022499B; CCTI case: AEO99TRN.D022499A.

The results above suggest that the proposed CCTI tax initiatives for LDVs would not yield many additional AFV/AVT sales above those projected in the reference case. Consequently, most of the tax benefits would go toward consumer purchases that would have been made even without the proposed tax incentives—because of the sales mandated by the Low Emission Vehicle Program in California, New York, and Massachusetts. The CCTI tax initiatives would, however, provide additional incentives for manufacturers to comply with the mandates of the Low Emission Vehicle Program.

Why are the projected effects of the CCTI tax incentive program for LDVs so marginal? The answer is suggested by an analysis of the barriers to AFV/AVT penetration of the U.S. LDV market. Again, the following criteria are likely to be considered by prospective purchasers: (1) vehicle price, (2) cost of driving, (3) vehicle range, (4), top speed, (5) acceleration, (6) multiple fuel capability, (7) maintenance cost, (8) luggage space, and (9) fuel availability.

The most important consideration in consumer purchase decisions is vehicle price. In the reference case, at low production volumes of approximately 2,500 vehicles per year, the price of an electric, hybrid, or fuel cell vehicle is approximately $10,000 higher than that of a comparable gasoline vehicle. And even at sales volumes approaching 25,000 units per year, the cost differential still would be about $7,000 for electric vehicles, $7,000 for hybrids, and

$2,000 for fuel cell vehicles. Although the CCTI tax initiative would reduce the vehicle price, the effective reduction would amount to only about $4,000 off the reference case price of $10,000 for a compact fuel cell vehicle in 2005.[42]

In terms of driving costs, even with the lower vehicle prices at higher sales volumes, consumers may not receive sufficient payback through fuel savings to encourage AFV/AVT purchases if gasoline prices remain low.[43] Because 75 percent of the vehicles purchased in the United States are still on the road after 10 years, vehicle purchases generally are long-run decisions. The pattern of fuel prices over the recent past can be expected to raise doubts among consumers about the prospects for long-term increases in the future. Gasoline prices rose by 31.6 cents a gallon (in 1997 dollars) from 1973 to 1974, but by 1978 they were only 14.5 cents above 1973 levels. From 1978 to 1979, prices rose by 47.1 cents a gallon, only to fall below 1978 prices by 1983. Although consumers switched their purchasing patterns toward smaller cars and away from larger cars during the oil crises, those short-term fuel price spikes caused only short-run adjustments in vehicle purchasing patterns. Moreover, although AFV/AVT fuel economies (miles per gallon) are expected to be significantly higher than those of conventional gasoline vehicles, their driving costs per mile also are likely to remain significantly higher. As long as gasoline prices remain low, electricity will be a more expensive vehicle fuel. Hydrogen currently is more than twice as expensive as gasoline and, at any rate, is not available to the average consumer.

Vehicle range, top speed, and acceleration may also pose barriers to consumer acceptance. For example, electric vehicles can travel a maximum of one-fourth to one-sixth the distance that a conventional gasoline vehicle can travel before refueling. Top speeds generally are similar for the advanced technologies and gasoline vehicles, but all the new technologies have significant acceleration drawbacks that would require higher horsepower and larger engines to match the performance of conventional vehicles, which in turn would reduce their fuel economy.

After price, reliability or quality is often cited as the most important purchase criterion by consumers, who are wary of high maintenance costs. Unfortunately, the maintenance costs for AVT vehicles are virtually unknown. Mechanics are not currently being trained to repair and maintain the vehicles, and the availability and cost of replacement parts are uncertain. For present-day electric vehicles, which use lead-acid batteries, the batteries must be replaced approximately every 3 years at a cost of more than $10,000 for each replacement. Nickel-metal hydride batteries provide 50 percent greater vehicle ranges and last twice as long as lead-acid batteries, but they cost more than four times as much. Lithium-ion batteries can extend vehicle ranges to approximately three times those of lead-acid batteries and may not require replacement during the life of the vehicle, but their costs can be as much as 10 times that of a lead-acid battery.

[42]There is a great deal of uncertainty associated with incremental vehicle cost for both present advanced technology vehicles as well as in the future. For example, Toyota has said that the Prius will sell for more than $15,500 but less than $22,000 (see *Electric Vehicle Today*, August 27, 1998). *Automotive Issues* has estimated the Prius incremental cost to be approximately $15,000 (see *Automotive Issues*, Trends Issue, March 1998).

[43]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998), p. 116.

Interior volume and luggage space are also of concern to potential purchasers. Electric vehicles are likely to be limited in availability to smaller vehicles, because the expense of batteries needed to power larger vehicles would be prohibitive. Two electric minivans are currently on the market (see Table 1), but their purchase price is approximately $100,000 per vehicle. Fuel cell vehicles, in contrast, may only be available in the larger size classes, because of the size and weight of the fuel cell stacks.

Finally, fuel availability is one of the most important barriers to AFV/AVT market penetration. Infrastructure problems are important issues for the production and distribution of both methanol and hydrogen fuel. Methanol refueling stations are sparsely scattered in most States, although more are available in California. Electricity is available in nearly all U.S. homes, but the recharging time for most electric vehicles is between 3 and 8 hours.

In addition to the above concerns that are expected to dampen the enthusiasm of consumers for AFV/AVT purchases, emissions and environmental issues also pose significant hurdles for the new vehicle technologies. For example, electric vehicles are nearly emissions-free while in operation, but their ability to provide net emissions reductions depends on the primary energy source used to generate the electricity that fuels them. Coal-burning electricity generation provides few if any benefits relative to gasoline-burning vehicles. Still another environmental issue for electric vehicles is the potential impact of rapid production, elimination, and recycling of vehicle batteries on a large scale.

Emissions issues may also pose problems for diesel-electric hybrid vehicles. Advances in diesel technology have significantly reduced their noise and emissions of particulates, but high levels of nitric oxides and particulates may present significant health problems. EPA is currently revising its NO_x and particulate emissions standards as mandated by Congress under the Clean Air Act Amendments of 1990, and recent regulations passed by the California Air Resources Board are expected to eliminate diesel technologies from further consideration as solutions to higher fuel economy unless they use advanced catalysts and/or new types of low-sulfur or reformulated diesel fuel.

Advanced low-sulfur, low-benzene, and reformulated fuels in combination with advanced catalysts are currently being explored, and Fischer-Tropsch fuels (derived from refinery waste products and natural gas) also are potential candidates for use with advanced diesel technologies. Studies have shown that these advanced diesel fuels and derivatives can reduce both NO_x and particulate emissions by as much as 80 percent. At present, however, the fuels are not cost-competitive with either gasoline or diesel fuel.

Renewable Electricity Generation

Background

The proposed CCTI tax initiatives include several provisions aimed at increasing the utilization of zero-carbon fuels, such as wind and biomass, in the generation of electricity. It is hoped that the programs will spur the development of zero-carbon generating technologies and lower their costs in the future. Such incentives for renewable fuels are not entirely new. The Energy Policy Act of 1992 (EPACT, P.L. 102-486) established production incentives for new biomass and wind-powered generating facilities, but their impact has been fairly small.

EPACT provides qualifying new wind and biomass facilities with a 1.5-cent subsidy (adjusted for inflation since 1992) for each kilowatthour of electricity they produce during their first 10 years of operation. The subsidy reduces the cost of new wind plants by 20 to 25 percent and the cost of new biomass plants by 20 to 30 percent. To qualify, a new wind plant must have come on line between December 31, 1993, and June 30, 1999 (June 30, 2003, for those brought on by publicly owned entities). For qualifying biomass plants the beginning date was December 31, 1992. The program differs slightly for facilities built by private and public entities. For private companies, the subsidy is paid through a production tax credit (PTC), and biomass plants must be closed-loop facilities to qualify.[44] For public entities, the subsidy is paid by DOE through a renewable energy production incentive (REPI), and the definition of qualifying biomass facilities is much broader.

So far, the REPI and PTC have resulted in limited additions of new biomass and wind generating capacity. There has been no biomass capacity built in response to the PTC because of the restriction to closed-loop fuel sources. From 1994 through 1998, 283 megawatts of new wind-powered generating capacity entered service, 8 megawatts under the REPI and 275 under the PTC.[45] While the REPI and PTC programs likely influenced the decisions to build the facilities, other programs, including State mandates to build certain types of capacity, also probably played a role. There was little response to the programs in their early years. In fact, only 80 megawatts of the 283 megawatts added entered service before 1998. However, more than 600 megawatts of wind capacity—most believed eligible for the PTC—are projected to enter service in 1999.[46] In addition, 60 megawatts of repowered wind capacity in 1998 and 200 megawatts in 1999 are expected to be eligible for the PTC.[47]

[44]Closed-loop biomass facilities are fueled by organic material from crops that are planted exclusively for use in electricity production.

[45]Federal appropriations identify REPI recipients, but no data are available to identify generating capacity using the PTC; therefore, EIA assumes that all new wind capacity not receiving REPI payments uses the PTC.

[46]NEMS does not distinguish month of initial service. As a result, it is assumed that all new wind capacity entering service in 1999 is accorded the PTC under current legislation.

[47]A May 24, 1994, ruling states that a facility may qualify as "originally placed in service" even though it contains some used property, provided the fair market value of the used property is not more than 20 percent of the facility's total value. Most wind repowering projects should qualify for the PTC under this ruling.

In total, excluding the repowered units, some 875 megawatts of new wind generating capacity will have entered service during the EPACT PTC time frame; however, the extent to which the PTC influenced the observed growth in U.S. wind power through 1999 is unclear. During the first 4 years of the EPACT program, through 1997, very little new wind capacity was built, suggesting that the PTC alone may not have been sufficient to spur much growth in U.S. wind capacity. On the other hand, the stronger growth in 1998 and 1999 appears to have been propelled largely by State mandates, testing programs, and green power or other environmental initiatives. For example, in Minnesota, the State legislature and the public utility commission have ordered Northern States Power Company to add a significant amount of wind capacity. In 1998, more than half of the wind capacity added resulted from State mandates, and in 1999 more than three-fourths of the expected additions are under State requirements of one type or another. EIA is not aware of any wind generating facility entering service during the EPACT PTC time frame based solely on its project economics—even with the PTC subsidy.

Because so little capacity has been added, the revenue effects of the existing PTC and REPI programs are fairly limited. For wind power, PTC-related tax expenditures (tax revenues not received) through 1997 are estimated at less than $4 million, rising to $16.3 million in 1998. If the capacity expected to be added in 1999 is built before the expiration of the PTC, tax revenue reductions this year could rise to a maximum of $55.6 million. For biomass, Federal appropriations data indicate that REPI payments have been made to two biomass plants and eight landfill gas plants. REPI payments for biomass and landfill gas plants were $2.7 million in 1998.

Climate Change Technology Initiative

The CCTI extends the PTC for wind and biomass for 5 years, through June 30, 2004. In addition, the proposal would expand the biomass subsidy while slightly narrowing the wind subsidy. The definition of eligible biomass sources is broadened from only closed-loop biomass to include any solid, nonhazardous, cellulosic waste material that is segregated from other waste materials, and that is derived from the following forest-related sources: mill residues, pre-commercial thinnings, slash, and brush other than old growth timber. Also included would be pallets, crates and dunnage, trimmings, and agricultural byproducts or residues. In essence, this would expand the credit to those facilities that can use wood residues and wood wastes to generate electricity for sale to customers (self-generation does not qualify).

In addition to broadening the definition of eligible biomass, the proposal also provides a 1.0-cent PTC (also adjusted for inflation) for biomass that is co-fired in coal plants to produce electricity during the period July 1, 1999, through June 30, 2004. This credit would apply to all facilities that are co-firing biomass with coal, including those that began doing so prior to the PTC. For wind, although no final decisions have been made, it is currently believed that the repowering of existing capacity will be excluded from the PTC extension. Therefore, EIA has assumed that no additional existing wind generating capacity (beyond the 260 megawatts covered under current rulings) will receive credits for repowering.

Methodology

For this analysis, the PTC for wind and biomass was modeled in the NEMS electricity market and renewable fuels modules, with no feedback from other NEMS modules. Because the vast majority of biomass-based cogeneration is consumed on site, and therefore is not eligible for the credit, cogeneration was not considered in the analysis. In order to test the potential impacts of the CCTI, it was assumed that the PTC would be extended by 5 years, through 2004.

In the reference case for the analysis, the date of commercial availability for new biomass-fired units (expected to be integrated gasification combined-cycle facilities) was assumed to be 2005, past the period in which new units would qualify for the CCTI tax credit. For the CCTI analysis case, it was assumed that the industry would respond to the availability of the PTC by advancing the date of commercial availability for the technology to 2004. Fuel inputs were also expanded to include currently available wood residues and waste in addition to dedicated energy crops, which are assumed not to be available until 2010. While it is plausible that the PTC could encourage the construction of some older, less efficient direct-fired biomass boiler units, that technology was not specifically modeled. It is believed that the relatively low efficiency of direct-fired units would make them economically unattractive.

The model was also to allow coal plants to use biomass for a portion of their fuel if it was economical. It was assumed that a coal plant could use biomass to displace up to 4 percent of the coal it would normally use. Experience has shown that a typical coal-fired boiler can fire from 3 to 5 percent biomass without a costly retrofit. Coal plants can consume larger shares of biomass, perhaps as much as 10 to 15 percent of their fuel, if new fuel handling systems are added and boiler firing equipment is modified. Such modifications are expensive, however, and the short length of the PTC for biomass co-firing makes it unlikely that plant operators would be willing to make such investments. An offline analysis was performed to match the availability of relatively low-cost biomass with the amount of coal capacity in a region. The maximum co-firing share allowed in any region was the minimum of the available low-cost biomass and the available coal capacity (assuming the use of 4 percent biomass). Because there were regions where the match was not good—large amounts of biomass but few coal plants, or many coal plants but little biomass—the maximum amount of coal that could be displaced by co-firing with biomass was determined to be 2.3 percent nationally. Among the regions in the model, it varied from 0 to 4 percent.

Results

Biomass

The extension and broadening of the PTC for biomass in the CCTI analysis case does encourage a small amount of new development (Table 19). In the reference case (without the extended PTC), in addition to the 358 megawatts of biomass generating capacity added between 1993 and 1998, 250 megawatts are projected to be added through 2004.

However, most of the projected additions result from an off-line analysis of State requirements to include renewable capacity in response to renewable portfolio standards and other State mandates. Those plants are not eligible for the EPACT PTC, because they are not closed-loop biomass facilities. In the CCTI case, 340 megawatts (about 17 percent) more capacity is projected to be added through 2004 than in the reference case. By 2010, biomass capacity is 360 megawatts higher in the CCTI case than in the reference case.

Table 19. Projected Effects of the CCTI Biomass Energy Production Tax Credit, 2005 and 2010

Projection	1997	2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case
Biomass-Fired Generating Capacity (Gigawatts)[a]	1.66	1.97	2.31	2.15	2.51
Biomass-Fired Electricity Generation (Billion Kilowatthours)	4.21	9.60	12.00	10.90	13.50
Total U.S. Carbon Emissions (Million Metric Tons)	1,480.0	1,676.1	1,675.9	1,786.0	1,785.4
Tax Revenue Reductions (1997 Dollars)	—	—	70.0	—	60.5

Source: Energy Information Administration, National Energy Modeling System runs CCTIBASE.D032599E and CCTIBIO.D032599E.

Biomass generation is projected to be about 2.4 billion kilowatthours higher in 2005, and 2.6 billion kilowatthours higher in 2010, in the CCTI case than in the reference case. Carbon emissions in 2005 are 0.2 million metric tons lower in the CCTI case than in the reference case. The 2.6 billion kilowatthour increase in biomass generation amounts to less than 0.1 percent of total generation in 2010, and the impact on carbon emissions is 0.6 million metric tons. The addition of this modest amount of capacity is not sufficient to reduce carbon emissions from baseload coal and natural gas generation.

In 2005, the reduction in projected tax revenues in the CCTI case is $70 million. About 42 percent of the tax credits in the CCTI case go to capacity that is also projected to be built in the reference case, without the extended PTC. By 2010, the tax revenue reduction is projected to be $60.5 million, and the share going to capacity built in the reference case drops to about 33 percent of the total. Of the approximately 590 megawatts receiving the credit in 2005 in the CCTI case, 250 megawatts are built in the reference case. In 2010, about 510 megawatts continue to receive the credit in the CCTI case, and only 170 megawatts of that capacity is projected to be built in the reference case. Because a given plant's production is eligible for the PTC for 10 years after the plant is placed in service, the projected tax revenue reductions are lower in 2010.

The biomass co-firing provision of the CCTI has a more significant impact than the PTC for new plants; however, because the co-firing credit expires in 2004, the impact is not long lasting. In 2004, electricity generation from co-fired biomass is projected to be 29.7 billion kilowatthours in the CCTI case, about 2.5 times the reference case level (Table 20). As a result, total carbon emissions are 4 million metric tons lower in that year. The cost of the subsidy is estimated to be about $330 million in tax revenue reductions, and only a small portion of the total (about 9 percent) goes to facilities that would have used biomass co-firing without the PTC.

Table 20. Projected Effects of the CCTI Biomass Energy Co-firing Tax Credit, 2004, 2005, and 2010

Projection	1997	2004		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI Case
Co-fired Electricity Generation (Billion Kilowatthours)	0.10	12.00	29.70	8.10	8.10	8.60	8.50
Total U.S. Carbon Emissions (Million Metric Tons)	1,480	1,656	1,652	1,676	1,676	1,786	1,786
Tax Revenue Reductions (1997 Dollars)	—	—	330.0	—	0.0	—	0.0

Source: Energy Information Administration, National Energy Modeling System runs CCTIBASE.D032599E and CCTICOF.D032599B.

Although it has been assumed that the expiration of the PTC for co-firing after 2004 would return co-firing to its reference case levels, it is possible that the higher levels could be maintained at least in part. For example, electricity producers might maintain their relationships with biomass fuel suppliers once the PTC has induced such purchases. A recent example of such a change is the use of low-sulfur subbituminous coal in boilers originally designed only for bituminous coal, encouraged by the sulfur emission reduction requirements of the Clean Air Act Amendments of 1990 (CAAA90). Before the CAAA90 requirements were implemented, it was believed that the plants could not burn subbituminous coal.

The results presented here hinge on the commercial availability of biomass gasification technology and the development of the needed biomass fuel supply within the PTC time frame. The near-term focus of the PTC will make this a challenge. There is uncertainty concerning the assumption in the CCTI case that 3 or 4 new gasification-type plants can be operating by 2004, which may be optimistic given the current state of the technology. There is also a degree of uncertainty with regard to biomass fuel supply, and the economics will be highly site specific. Anecdotal information suggests that new units recently or about to come on line are using some specialized low-cost waste stream. The site-specific nature of the economics is true for co-firing as well. Other considerations include low sulfur emissions from the Minnesota alfalfa plant and green power programs.

Finally, for both the biomass and wind results (see below), the actual tax revenue losses may be less than estimated in the CCTI case even if all the projected new capacity enters service. To the extent that new generating capacity is ineligible for the PTC because of minimum tax rules or other requirements effectively disallowing the benefits, enters service later in its initial year or is delayed until a later year, or performs below the 33-percent capacity factor assumed for new wind capacity or the 80-percent capacity factor assumed for new biomass capacity, the tax revenue reductions could be less than estimated here.

Wind

In the reference case, new wind generating capacity is expected to be built after 1999 despite the expiration of the EPACT PTC. In response to State mandates, renewable portfolio standards, and other requirements, 537 megawatts of new wind capacity is projected to be added from 2000 through 2004. The NEMS model does not add any wind capacity in this period based solely on economics. Wind technology costs and performance are expected to improve, but they still are not expected to be competitive with new natural gas plants in most situations.

Extending the PTC through 2004 leads to only modest additions of new wind generating capacity beyond those projected in the reference case. In the CCTI case, U.S. wind generating capability is only 50 megawatts above reference case projections (Table 21). The minimal cost declines induced by the addition of this capacity result in little additional wind generating capacity after 2004 and only 10 megawatts more after 2010.

Table 21. Projected Effects of the CCTI Wind Energy Production Tax Credit, 2005 and 2010

Projection	1997	2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case
Wind Generating Capacity (Gigawatts)[a]	1.88	3.24	3.29	3.39	3.44
Wind Electricity Generation (Billion Kilowatthours)	3.41	7.24	7.39	7.69	7.84
Total U.S. Carbon Emissions (Million Metric Tons)	1,480.0	1,676.1	1,676.1	1,786.0	1,785.9
Tax Revenue Reductions (1997 Dollars)	3.9	52.3	81.1	0.0	22.3

Source: Energy Information Administration, National Energy Modeling System runs CCTIBASE.D032599E and CCTIWIND.D032699A.

The tax revenue consequences of the CCTI are similarly modest for wind power when applied only to the CCTI-induced additional capacity, totaling only $2.4 million in 2005. The total tax revenue effects of the PTC extension are much greater, however, because the 537 megawatts of wind capacity expected to be added in the reference case can also take advantage of it. As a result, if all the eligible plants take advantage of the extended PTC, the cost could reach $28.8 million per year in 2005. Because little new wind capacity is expected to be encouraged by the extended PTC, the effect on carbon emissions is small.

The PTC could indirectly lead to new capacity additions not captured in the results presented here. Just as the new wind plants added during the EPACT PTC time frame appear to have been encouraged by the combination of the PTC, State mandates, and other incentive programs, the combined stimulus may continue with the extension of the PTC. Without the PTC extension, the other incentive programs will be more costly and may decline. Alternatively, green power programs and utility testing programs may grow if the PTC is extended. Some consumers may be willing to pay a small premium to purchase green power, including as wind power, but if the PTC is not extended the premium required may exceed what they are willing to pay. Similarly, some power companies have been experimenting with new wind facilities to become familiar with the technology and test how they might use it within their systems. Their willingness to continue those efforts may grow if the PTC is extended.

Conclusion

In general, the incremental impacts of the proposed tax incentives in the CCTI are relatively small. Although the tax credits serve to reduce the initial costs of the energy technologies, empirical evidence indicates that most consumers are willing to invest in more efficient, but more expensive, equipment only if the higher initial costs are offset by lower fuel costs over a period of several years. Even with the tax credits, the payback period for most of the equipment covered in the CCTI proposals remains longer than consumers are willing to accept. Similarly, in the electricity generation sector, the proposed tax credits may affect some marginally competitive wind and biomass plants; however, new natural-gas-fired, combined-cycle plants generally retain an economic advantage. In addition, the more flexible operation of natural-gas-fired generating facilities provides a further advantage over wind generation.

3. Research and Development Support

Introduction

The Administration's Climate Change Technology Initiative (CCTI) proposes fiscal year 2000 funding for a number of programs for the research, development, and deployment of energy-efficient and renewable technologies, more efficient electricity generation technologies, and carbon sequestration research. Many of these are continuations of ongoing programs. The total budget request for CCTI research, development, and deployment programs is almost $1.4 billion, an increase of $347 million over the estimated fiscal year 1999 budget. These initiatives include basic research and development for buildings, industry, transportation, and electricity generation technologies and carbon sequestration and also a variety of programs to encourage the adoption of the technologies, including voluntary and information programs, partnerships, and consultations.

This analysis does not assess the impact of the proposed $1.4 billion funding, because it is difficult, if not impossible, to directly relate levels of funding for research and development to specific improvements in the characteristics and availability of energy technologies. It is likely that some of the proposed technologies will not be successful, and foreseeing the successful technologies is not possible. It is also not possible to establish a correlation between information and voluntary programs and their impacts on technology development and deployment in the past or in the future. As a result, many of the research and development programs in CCTI are addressed in qualitative terms in this analysis. In some cases, the impacts of ongoing technology development in the reference case projections or in history are assessed. For several of these programs, the potential impacts are analyzed quantitatively by incorporating the program goals and estimating their impacts on technology penetration, energy consumption, and carbon emissions.

Buildings

The CCTI proposed investment package for the research, development and deployment of renewable energy technologies and energy-efficient practices includes $273 million in funding for buildings technology. The proposal provides funds for Department of Energy (DOE), Environmental Protection Agency (EPA), and Department of Housing and Urban Development (HUD) programs and represents a 59 percent increase over fiscal year 1999 spending on buildings technology. Initiatives range from efficiency standards to voluntary efficiency and partnership programs such as Energy Star Products and Energy Star Buildings to programs furthering the research, development, and deployment of new and renewable technologies, such as advanced lighting, space conditioning and photovoltaic energy systems. Estimating the current or future impact of these types of programs is very difficult; thus a more qualitative treatment of these programs will be presented here. The following discussion describes some of the initiatives and the approach used to analyze their potential impacts on residential and commercial energy use and carbon emissions. The energy efficiency appliance standards program is addressed separately in Chapter 4. The programs described are just a sampling of the many initiatives included in the funding proposal for buildings technology.

The total budget request for CCTI programs in fiscal year 2000 includes funding for existing programs, as well as increases in funding for various programs and research and development (R&D). The reference case includes expected energy savings for the funding levels of programs in place at the time the reference case forecasts were developed. Many programs, such as R&D, are difficult to explicitly represent in the NEMS modeling framework. Impacts of R&D are generally represented as cost declines in efficient equipment and marginal improvements in building shell efficiency over time. The programs listed below, to the extent that they existed at the time the reference case was developed, all contribute to the increased efficiency projected over time. To illustrate the amount of energy savings due to increased efficiency in the buildings sector, the reference case is compared to a "frozen efficiency" case, which sets equipment and building shell efficiency at their respective 1999 levels. By 2010, 580 trillion Btu (3 percent) of delivered energy is saved on an annual basis in the buildings sector, as current policies and programs act to increase energy efficiency in the reference case.[48] The following section highlights some of the CCTI programs and indicates energy savings realized in the reference case, where appropriate. For some of the programs, a more qualitative approach is taken, since program effectiveness is difficult to judge.

Partnership for Advancing Technology in Housing (PATH)

The goal of the PATH program is for Federal agencies to "work with the buildings industry to develop, demonstrate, and deploy housing technologies to make homes 50 percent more energy-efficient within a decade and to enable the retrofitting of at least 15 million existing homes within a decade to make them 30 percent more efficient." In addition, DOE's Building America program will help build 2000 energy-efficient homes and disseminate the results to the builders of 15,000 other houses. The goals associated with this program are similar to those outlined in the tax credit proposal for energy-efficient new homes, albeit at specific penetration levels.

To demonstrate the impact that the PATH program could have if it were fully successful, a scenario was established where the goals of the PATH program for new construction were fully realized. The major goal of PATH is to build homes that are 50 percent more energy efficient than today's newly constructed homes. By 2010, it is assumed that 70 percent of all new homes are constructed at this level of energy efficiency. For this scenario, it is assumed that the penetration of these new homes was "back-loaded" to the target date. Since very few homes are constructed at this efficiency level at the present time, it was assumed that it would take several years for the program to take hold,

---

[48]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998), Tables F1 and F2.

and that larger increases in penetration occur in the out years. It should be noted that any homes built under the PATH program during 2000-2004 would qualify for the energy efficient new home tax credit mentioned in Chapter 2, although the tax credit analysis in Chapter 2 did not consider the PATH goals. Table 22 shows the energy, carbon, and energy bill savings from meeting the goals of the PATH program. By 2010, annual energy savings total 96.5 trillion Btu, saving Americans $909 million and abating 2 million metric tons of carbon. If the PATH goal is maintained through 2020 the program could save 429.4 trillion Btu, reducing energy bills by $3.9 billion and abating 8.9 million metric tons of carbon.

Table 22. Projected Energy Savings and Carbon Emissions Reductions for Successful PATH Program Goals in New Housing, 2005 and 2010

Projection	1997 Total	2005 Savings	2010 Savings
Delivered Energy (Trillion Btu)	10,921	11.5	96.5
Energy Expenditures (Million 1998 Dollars)	139,898	114.1	909.2
Carbon Emissions (Million Metric Tons)	285.6	0.3	2.0

Source: Energy Information Administration, National Energy Modeling System run RSPATH.D032399C.

Energy Star Products

The Energy Star Products program promotes the use of energy-efficient appliances through labeling efficient products and educating consumers about the benefits of energy efficiency. Current programs cover products such as air conditioners, televisions, and office equipment. The proposed fiscal year 2000 budget calls for new funding to support the launch of 25 new Energy Star product lines.[49] Possible candidates for the Energy Star label include compact fluorescent lamps, ventilation fans, ducts, water coolers, and internal power supplies. Since it is unknown what products would be added to the Energy Star lineup or the extent of the resulting energy savings, two examples of recent additions to the Energy Star lineup are provided to illustrate program potential. A quantitative assessment of one of the latest additions to the family of Energy Star programs, namely televisions (TVs) and videocassette recorders (VCRs) is followed by a qualitative discussion of the new Energy Star program for refrigerated vending machines.

The Energy Star TVs and VCRs program was designed to cut the amount of power each device used while in standby mode. The reference case explicitly includes an estimate for the effect of this program. Over the next 10 years, it is projected that 168 trillion Btu of electricity will be saved (cumulatively), accumulating $3.9 billion dollars of energy bill savings, and abating 8.9 million metric tons of carbon cumulatively (Table 23).

[49] "Report to Congress on Federal Climate Change Expenditures," p. 11.

Table 23. Projected Electricity Savings and Carbon Emissions Reductions Attributed to the Energy Star TV/VCR Program in the Reference Case, 2005 and 2010

Projection	1997 Total	2005 Savings	2010 Savings
Delivered Electricity (Trillion Btu)	3,656	15.0	30.0
Electricity Expenditures (Million 1998 Dollars)	91,900	345.4	681.0
Carbon Emissions (Million Metric Tons)	285.6	0.8	1.5

Source: Energy Information Administration, National Energy Modeling System runs AEO99B.D100198A and BLDCCTI.D031999B.

New funding will also support the launch of new Energy Star product lines like the program to improve energy efficiency in refrigerated vending machines that is just getting started. The goals for the new voluntary energy efficiency program for refrigerated vending machines are to transform the vending market and improve the standard for vending machine energy use by 25 percent. One recent estimate puts annual electricity consumption by refrigerated vending machines at about 7.5 billion kilowatthours per year[50]. If the program goals were met, annual electricity consumption for these machines would be reduced to about 5.6 billion kilowatthours per year, saving about 1.9 billion kilowatthours per year for this Energy Star product line. The typical lifetime of a vending machine is 7 to 10 years, so if the market were fully transformed, it would take 7 to 10 years from the time the efficient vending machines are widely available to realize the entire 25 percent savings. Some energy savings could be realized earlier if owners decide to install energy efficient lighting components when existing machines are refurbished, normally after three to five years of service. Transforming the market may present quite a challenge considering that a different company than the one that pays the operating costs most often owns the vending machines.

Million Solar Roofs

DOE's Million Solar Roofs (MSR) program is an example of a national voluntary program aimed at increasing the penetration of solar technologies, both PV and solar thermal systems. The MSR program goal is to facilitate the installation of one million solar roofs by 2010. Among the activities fostered to accomplish this goal, the program commits its partners to a variety of actions. Some of the actions MSR partners can undertake include:

- Committing to install solar equipment in a certain number of structures

[50]Program goals and estimate of annual electricity consumption are from "Shaking out savings," Association of Energy Services Professionals, *Strategies*, Winter 1999, Vol. 10 No. 1, p. 7. The consumption and inventory figures in this article are actually closer to figures for canned beverage vending machines found in Arthur D. Little, Inc., *Energy Savings Potential for Commercial Refrigeration Equipment* (June 1996) which estimated annual consumption for canned beverage vendors at about 7 billion kilowatthours in 1994.

- Undertaking activities to reduce barriers to the adoption of solar technologies by identifying financial incentives for solar installations, establishing net metering for PV, and modifying codes and standards for solar installations.

- Implementing training and information sharing programs.[51]

Table 24 details the energy, carbon, and energy bill savings from a successful realization of the MSR program goals. It should be noted that roughly two-thirds of the program goal is included in the reference case since these units have already committed to participate in the program.

Table 24. Projected Energy Savings and Carbon Emissions Reductions for Successful Million Solar Roofs Program

Projection	1997 Total	2005 Savings	2010 Savings
Delivered Energy (Trillion Btu)	10,921	6.8	12.4
Energy Expenditures (Million 1998 Dollars)	139,898	146.8	256.0
Carbon Emissions (Million Metric Tons)	285.6	0.4	0.6

Source: Energy Information Administration, National Energy Modeling System runs BLDCCTI.D031999B and RCNOSOL.D033199A.

The impacts of the following programs are difficult to quantify because of the voluntary, informational, and/or cross-cutting nature of program activities. A qualitative discussion is presented to describe the types of services and benefits provided by funding these programs.

Energy-Efficient Buildings and Energy Smart Schools

Energy Star programs also exist for commercial buildings and newly constructed homes. The Energy Star Buildings and Green Lights Partnership is a voluntary partnership between U.S. organizations, the U.S. Department of Energy, and the U.S. Environmental Protection Agency to promote energy efficiency in commercial and industrial facility space. Participants receive technical information, customized support services, public relations assistance, and access to a broad range of resources and tools. Program literature states that U.S. organizations could save an estimated $130 billion by 2010 and reduce their buildings energy use by up to 30 percent. As of November 1998, the program reports 3,000 organizations participating in the partnership. The program focuses first on energy-efficient lighting upgrades, typically the most cost-effective improvement for commercial buildings. This program has enjoyed some success with 2.8 billion feet of commercial and industrial floorspace upgraded (primarily lighting upgrades) by the

[51]See the Million Solar Roof web site, www.eren.doe.gov/millionroofs/.

end of 1997. EPA reports $514 million in annual energy cost savings from these completed upgrades.[52] The NEMS commercial module includes effects of this program in its reference case assumptions.

Energy Smart Schools is a new program announced in October 1998 that would garner some of the benefit of the increased funding in the CCTI funding proposal. The initiative proposes to bring together public and private sector resources to cut schools' energy bills 25 percent by 2010, providing savings to be reinvested in education. Energy Smart Schools is primarily an informational and outreach program. This program cuts across several other U.S. Department of Energy programs, helping individual schools access existing programs such as Rebuild America, Energy Star, the Million Solar Roofs initiative, and other national, state and local programs that provide direct technical assistance, tools and training to schools. Although the program goal is explicitly stated, the potential effects of any informational program are difficult to quantify. Projecting the effects of this program is complicated by the fact that many of the actual savings will be the direct result of other programs and will be counted by those program sponsors as well.

Federal Energy Management Program

The mission of the Federal Energy Management Program (FEMP) is to reduce the cost of Government by advancing energy efficiency, water conservation , and the use of solar and other renewable technology. This mission has been shaped by several Federal laws and Executive Orders, including the Federal energy reduction goals set forth in the National Energy Policy Act of 1992 (EPACT) and Executive Order 12902 in 1994. EPACT mandates a 20 percent reduction in energy consumption in Federal buildings by fiscal year 2000, when measured against an fiscal year 1985 baseline on a Btu-per-square-foot basis, and Executive Order 12902 requires agencies to achieve a 30 percent reduction by fiscal year 2005. FEMP's activities to help agencies meet those goals include creation of partnerships, resource leveraging, technology transfer, and training and support. The fiscal year 2000 budget request includes an increase in funding of $8 million (34 percent) over the 1999 FEMP budget. The nature of FEMP as an organization providing services to other Federal agencies makes it difficult to quantify the effects of additional funding. However, an indication of the benefits gained through FEMP funding can be provided by outlining the progress made toward helping Federal agencies meet their energy reduction goals:

- By the end of fiscal year 1998, the Government had decreased energy consumption in buildings by 15.2 percent per square foot since 1985- halfway to its goal of achieving a 30 percent reduction by 2005.

- Energy efficiency efforts have resulted in a cumulative savings of $6.3 billion in the Nation's energy bill compared to a 1985 baseline.

---

[52]U.S. Environmental Protection Agency, *Helping Build a Better Future—ENERGY STAR Buildings and Green Lights 1997 Year in Review* (Washington, DC, April 1998).

- Carbon emissions from energy used in buildings fell by 2 million metric tons from 1985 to 1996.Funding increases are aimed at accelerating the use of innovative multi-billion-dollar contracts that leverage private sector funds for Federal savings, increasing procurement of energy efficiency and renewable energy products, expanding the opportunities for solar power and addressing Federal energy opportunities of utility restructuring and green power as well as many other FEMP activities.[53]

Research and Development of Energy-Efficient Buildings Technologies

The fiscal year 2000 budget request includes an increase of $49 million over the 1999 budget (51 percent) for the DOE Building Technology Program. Included in this request is funding for programs such as Building America, Rebuild America, enhanced appliance standards, and research and development (R&D) of more efficient building equipment and appliances. Successful R&D can provide substantial energy savings to the buildings sector, provided the end products are marketed and priced appropriately to the consumer. Key technologies included in the DOE R&D portfolio include low-power sulfur lamps, advanced heat pumps, chillers and commercial refrigeration, fuel cells, insulation, building materials, and advanced windows. It is difficult to assess the impact that the increased R&D budget might have on future energy consumption. Predicting winners and losers in technological development is far from a science (for example, predicting the outcome of Beta versus VHS in video tape recording). Solar photovoltaics, for example, have experienced extreme cost declines over the past decades, however their penetration into the market remains very small due to declining fossil energy prices and unfamiliarity with the technology, along with many other reasons. It is for these reasons that EIA does not attempt to estimate energy savings from a dollar amount spent on technology-related R&D. Where clear program goals are associated with the dollar amounts, energy savings can be attributed to completely successful R&D spending (see PATH section above). It should also be noted that successful R&D can play a major role in improving the economics of most of the other programs included in the CCTI proposal. If major short-term progress is made in developing price-competitive energy-efficient alternatives to today's technologies, then all of the CCTI programs stand to benefit with increased market penetration. For example, price-competitive super-insulating windows can go a long way to achieving the goal of reducing energy by 50 percent in new housing, allowing for a much less costly alternative for qualifying for the tax credits described in Chapter 2.

[53]Information on FEMP is available at web site www.eren.doe.gov/femp/.

Industry

This analysis does not attempt to quantify the energy or emissions impact of the Department of Energy's voluntary programs or research and development programs for the industrial sector. The following is a brief summary of the programs.

The Department of Energy industry initiative expands efforts to develop innovative technologies and production methods. This initiative is intended to increase industrial productivity and to reduce greenhouse gas emissions.

The Industries of the Future program works with the most energy-intensive industries to develop technologies to increase efficiency, lower greenhouse gas emissions, and improve industrial competitiveness. There are specific programs that fund collaborative research and development and the development of industry vision statements to guide future technology developments.

The Industries of the Future program also has incorporated several existing cross-cutting programs, including Motor Challenge, Steam Challenge, Compressed Air Challenge, and the CHP Challenge. These programs provide technical expertise and information on how to use the specific energy forms more efficiently. They are coordinated with several other efforts, including the ATS program, Industrial Assessment Centers, and the NICE3 program.

In the cogeneration area, the Department states that its program goal is to result in systems that are 15 percent more energy-efficient and 80 percent cleaner than conventional power stations, while also reducing electricity costs by 10 percent.

DOE also funds the development of battery-storage and power-quality systems to improve the continuity and quality of power service. According to DOE, poor power quality and interruptions cost industry $100 billion per year, but there is no incentive to do anything about it in the existing regulatory structure. DOE intends to promote the integration of distributed electricity sources into the grid by funding the development of uniform interconnection standards for distributed power generation, and by funding studies to identify barriers to wider use of distributed generation.

Transportation

Partnership for a New Generation of Vehicles

The Partnership for a New Generation of Vehicles (PNGV), a consortium of U.S. automakers and government partnerships, has set a fuel efficiency goal of a 80 miles per gallon (mpg) for a mid-sized sedan, with no loss of performance or increase in purchase price from a current mid-sized sedan while meeting or exceeding Federal safety and emissions standards. A prototype is expected by 2000 and a production prototype by 2004. Commercial sale of the vehicles would potentially come 1 to 3 years later, making the technology available between 2005 and 2007.

The CCTI research and development initiatives include a proposed funding increase of $24 million for the PNGV program, which currently receives $264 million in Federal funding annually. The National Research Council (NRC), which reviews the PNGV program goals and achievements each year, has made the following assessments:[54] (1) unless the PNGV program receives significantly more funding, its goals most likely will not be met. (2) Unless the program begins to focus on a few proven technologies, its goals will not be met. (3) The goal of a fuel-efficient mid-sized vehicle with a purchase price similar to that of a conventional gasoline vehicle most likely will not be met. Because the minimal increase in funding for the PNGV program proposed in the CCTI (less than 10 percent) is unlikely to alter the NRC's prognosis, no quantitative analysis of the CCTI proposal was conducted for this study.

Advanced Diesel Technologies for Light and Heavy Trucks

Background

The CCTI research and development initiatives include a proposal to provide funding for government and industry partnerships to develop advanced diesel cycle engine technologies for pickup trucks, vans, and sport utility vehicles and engine and vehicle technologies to improve the fuel efficiency of new heavy trucks. In 1998, diesel-powered light-duty vehicles (LDVs) captured only 0.01 percent of total U.S. LDV sales, significantly below their highest shares of 6.1 percent of auto sales in 1981 and 5.0 percent of light truck sales in 1982.

In 1997, Volkswagen began offering a Jetta sedan with a turbocharged direct injection diesel engine (44.95 mpg) in U.S. markets. Although the new diesel engine provided a 60-percent increase in fuel economy over the conventional gasoline Jetta (27.85 mpg), it was soon withdrawn from the market due to lack of sales. Volkswagen is now working on a new direct injection diesel automobile (the Lupo) with a fuel efficiency goal of 78 mpg.

---

[54]National Research Council, *Partnership for a New Generation of Vehicles: Fourth Report* (Washington, DC: National Academy Press, 1998).

Heavy trucks are an integral part of U.S. commerce and economic growth. In 1995, total expenditures for highway freight transportation (local and intercity trucks) were over $348 billion, accounting for 79 percent of the Nation=s freight bill and approximately 4.8 percent of gross domestic product.[55] On average, a heavy truck travels 37,600 to 86,500 miles each year.[56] Heavy trucks account for 79 percent of freight truck fuel usage, and freight truck travel accounted for some 16 percent of all fuel use in the transportation sector in 1997.

The stated goal of the CCTI proposal for light trucks is a 35-percent improvement in fuel efficiency above conventional gasoline vehicles by 2002 while meeting strict emissions standards. For heavy trucks the goal is to achieve a fuel efficiency of 12 mpg by 2004 for new diesel trucks while still meeting prevailing emissions standards.

Analytical Approach

Light Trucks

For this analysis, the NEMS AFV/AVT module was used to model the CCTI research and development initiative.[57] The following assumption was made in modeling the CCTI analysis case: the date of commercial availability for turbo diesel fuel injection technology was advanced to 2002 from 2005, with no change in vehicle prices.

Heavy Trucks

The NEMS freight truck module was used for this analysis. The freight truck module is a stock model that includes existing and future fuel-saving technologies as well as alternative-fuel vehicles. The model uses projected sales of freight trucks, fuel prices, and output for selected industries from the NEMS macroeconomic module to estimate freight truck travel demand, purchases and retirements of freight trucks, and fuel consumption. Sales of new trucks are estimated according to the assumed market penetration rates for existing and future technologies, competition with other technologies, sensitivity to fuel prices, and fuel economy improvement. Relative fuel economies are used to determine the market share of new truck purchases for each technology in each year of the projection period. Capital costs are converted to a fuel trigger price at which each technology is considered cost effective based on an assumption of a three year payback period with a 10 percent discount rate applied to average distance traveled per truck.

For the CCTI analysis case, the following characteristics of heavy trucks were added to the available technology choices:

---

[55]Energy Resources R&D Portfolio, Draft-2 (2/6/99).

[56]U.S. Department of Energy Office of Transportation Technologies, *Program Analysis Methodology* (Washington, DC, January 15, 1999), p. 21.

[57]For a more detailed description of the AFV/AVT module, see Chapter 2, page 35.

- **Engine Efficiency**: Currently the best engines have nominal efficiencies of 46 percent. In order to achieve the CCTI goals, it was assumed that engine efficiencies would be increased to 55 percent or higher (an improvement of about 20 percent). The direct injection diesel engine is the most viable near-term engine technology expected to be commercially available by 2006. For this technology to be commercialized, several underlying integrated technologies must also be developed: improved design for cylinders to handle higher pressures, additional exhaust heat utilization through improved turbo systems,[58] improved thermal management (less heat rejection), and lower engine friction.

  Emissions controls are the greatest barrier to the adoption of the direct injection diesel technology, especially with regard to NO_x and particulate matter. As the fuel efficiency of diesel engines improves, NO_x emissions also increase. To address this problem, three approaches are used: (1) in-cylinder process (combustion, air handling) to change the way the fuel is burned; (2) exhaust after-treatment to capture NO_x and particulates; and (3) altered fuel properties to reduce sulfur, which shortens the life of a catalytic converter. Current research on exhaust after-treatment includes particulate filters, NO_x catalysts, and plasma systems. To date, a prototype particulate filter has been developed, small NO_x catalysts have exceeded 50-percent reductions, non-thermal plasma devices have exceeded 70-percent reductions on a small scale, and engine efficiencies of approximately 52 percent have been achieved in test engines. In production engines, reductions of more than 50 percent for NO_x and 80 percent for particulate matter have been achieved.

- **Vehicle Design**: In order to achieve the CCTI goals, it was assumed that fuel efficiency improvements of between five and nineteen percent would be achieved through improvements in the design of heavy trucks. Several technologies are currently under investigation: reduced aerodynamic drag, reduced rolling resistance, and reduced losses related to auxiliaries and operating modes. To date, a research and development plan on heavy vehicle aerodynamic drag has been developed with industry, and a program has been started to compile data on the heating and cooling of the truck cab, with the goal of reducing idling time.

  In the area of aerodynamic drag, the goal is to reduce drag coefficients from the current value of 0.60 to less than 0.50. Cab and trailer modifications must be cost-effective and must not hinder maintenance, payload, or the ability to meet government regulations and overall size restrictions. Current research is focusing on computational analysis tools for use in cab/trailer development. In the near term the trailer, which traditionally has received less attention than the cab, will be the focus. The main goal is to reduce the backdraft, or vacuum, at the end of a trailer that creates drag. Examples of work being done include curving the top of the trailer and creating a cone at the end; however, in the first case, haulers are unwilling to give up freight capacity to create a curved trailer, and in the second case the trailer may not meet safety regulations or may become a maintenance issue. Another, more promising example is the use of compressors to blow air into the vacuum, creating an airfoil. Similar types

[58]Energy Resources R&D Portfolio, Draft-2 (2/6/99), p. 204.

of work are being done on rolling resistance, such as the use of "super single" tires to replace the common two-tire set.

Some of the major obstacles to rapid market penetration of these advanced technologies are ensuring that all State and Federal regulatory standards will be met, and ensuring that the return on investment will be realized within a short period of time.

Results and Discussion

Light Trucks

The results for the CCTI analysis case show that diesel vehicle sales amount to less than 2 percent of total sales in 2010 (Table 25). Consequently, projected light truck fuel consumption in the CCTI case amounts to a 25 trillion Btu reduction in total light-duty vehicle fuel consumption by 2010 (Table 26). As a result, the reduction in projected carbon emissions from transportation energy use in the CCTI case relative to the reference case is only about 0.1 million metric tons in 2005 and 0.4 million metric tons in 2010—representing just 0.06 percent of total carbon emissions for the transportation sector (Table 27).

Table 25. Light Truck Sales, 1997-2010
(Thousands)

Vehicle Type	1997	2002		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI Case
Diesel Direct Injection	0.0	9.3	70.8	38.7	130.3	174.6	224.6
Total Vehicle Sales	13,618	13,274	13,274	13,836	13,836	14,780	14,780

Source: Energy Information Administration, National Energy Modeling System runs AEO99B.D100198A and CCTITRN.D033199A.

Table 26. Light Duty Vehicle Fuel Consumption, 1997-2010
(Trillion Btu)

Fuel Type	1997	2002		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI Case
Gasoline	13,902	15,518	15,515	16,309	16,280	17,449	17,382
Distillate Fuel	7.43	6.93	11.14	12.48	33.15	46.89	90.86
Methanol	1.17	31.35	31.27	51.04	50.77	77.38	75.63
Ethanol	0.53	17.84	17.80	30.10	29.91	51.13	50.62
Compressed Natural Gas	11.91	108.8	108.8	172.9	172.8	234.4	234.17
Liquefied Petroleum Gas	20.97	60.50	60.45	104.5	104.41	154.6	154.57
Electricity	0.26	2.79	2.79	39.94	39.91	83.13	83.06
Hydrogen	0.0	0.0	0.0	0.0	0.0	0.01	0.01
Total	**13,945**	**15,745**	**15,747**	**16,719**	**16,711**	**18,096**	**18,071**

Source: Energy Information Administration, National Energy Modeling System runs AEO99B.D100198A and CCTITRN.D033199A.

Table 27. Transportation Sector Carbon Emissions by Fuel Type, 1997-2010
(Million Metric Tons)

Fuel Type	1997	2002		2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case	Reference Case	CCTI Case
Petroleum	461.9	521.8	521.8	552.0	551.9	600.8	600.3
Natural Gas	10.5	12.8	12.8	14.7	14.7	16.7	16.7
Electricity	2.9	3.3	3.3	5.2	5.2	7.6	7.5
Other	0.0	0.5	0.5	0.9	0.9	1.4	1.3
Total	475.3	538.5	538.5	572.8	572.7	626.3	625.9

Source: Energy Information Administration, National Energy Modeling System runs AEO99B.D100198A and CCTITRN.D033199A.

Turbo direct injection vehicles are approximately $1200 higher than a conventional gasoline vehicle. With large sales volumes approaching 25,000 units per year, the incremental costs decline to about $800 for turbo direct injection.

Emissions issues may pose problems for direct injection diesel vehicles. Advances in diesel technology have significantly reduced their noise and emissions of particulates, but high levels of nitric oxides and particulates still present significant health problems. EPA is currently revising its NO_x and particulate emissions standards as mandated by Congress under the Clean Air Act Amendments of 1990, and recent regulations passed by the

California Air Resources Board are expected to eliminate diesel technologies from further consideration as solutions to higher fuel economy unless they use advanced catalysts and/or new types of low-sulfur or reformulated diesel fuel.

Emissions issues are especially problematic for direct injection diesel technologies. Reduction of both NO_x and particulates has proven difficult, because reduction of one often increases the emissions of the other. Particulate traps are expensive and marginally effective in emissions reduction. Advanced catalysts are being developed, but they are very expensive. Two different avenues of catalyst research and development are currently being pursued: Argonne National Laboratory has developed a plasma membrane that can separate NO_x emissions into pure nitrogen and oxygen, and Daimler-Chrysler has developed an emissions after-treatment procedure that shoots a fine mist of urea into the exhaust, chemically changing NO_x to nitrogen and oxygen. Both catalysts are in the early stages of research.

Advanced low-sulfur, low-benzene, and reformulated fuels in combination with advanced catalysts are currently being explored, and Fischer-Tropsch fuels (derived from refinery waste products and natural gas) also are potential candidates for use with advanced diesel technologies. Studies have shown that these advanced diesel fuels and derivatives can reduce both NO_x and particulate emissions by as much as 80 percent. At present, however, the fuels are not cost-competitive with either gasoline or diesel fuel.

It is also important to note that electric, fuel cell, electric hybrids, and turbo direct injection vehicles are in direct competition with each other for market share. Model runs with the turbo diesel direct injection technology initiative and not the CCTI tax incentives resulted in fuel cell vehicle sales falling by 1.6 thousand units or by 38 percent compared to a model run with only the CCTI tax incentive electric vehicle, fuel cell, and electric hybrid vehicle scenario in 2010. Conversely, turbo diesels fall by 50 thousand units or 36 percent, by 2010 in comparison to the CCTI scenario. Therefore, it is very likely, that both CCTI scenarios when combined, will yield less than both added separately.

Heavy Trucks

The heavy-duty truck technology characteristics in Tables 28 and 29 make up a representation of the technologies considered to meet the increased efficiency goal. These characteristics were used in the NEMS transportation freight truck model, what is an economically price driven model. The adoption of a technology, once introduced, is assumed to gain market share over time. It is also important to note that the trucking industry is very sensitive to fuel prices and demands a relativity short payback period. The fleet owners also highly value reliability which will cause their technology adoption decisions to differ from decisions that would be made on economics alone.

Table 28. Heavy Truck Diesel Technology Characteristics in the Reference Case

Technology	Date of Commercial Availability	Capital Costs (1998 Dollars)	Maximum Potential Market Share (Percent)	Fuel Economy Improvement (Percent)
Improved Tires and Lubricants	1994	1,500	100	5
Electronic Engine Controls	1994	1,000	99	4
Electronic Transmission Controls . .	1994	800	98	1
Advanced Drag Reduction	1997	1,000	40	15

Source: Energy Information Administration, National Energy Modeling System run AEO99B.D100198A.

Table 29. Heavy Truck Diesel Technology Characteristics in the CCTI Analysis Case

Technology	Commercial Availability Date	Capital Costs (1998 Dollars)	Maximum Potential Market Share (Percent)	Fuel Economy Improvement (Percent)
Advanced Drag Reduction 2	2008	7,500	75	19
Reduced Rolling Resistance	2006	1,750	75	9
Improved Accessories	1998	1,000	50	5
Improved Engine Efficiency	2006	900	100	10

Source: 1998 Technology characteristics: U.S. Department of Energy Office of Transportation Technologies

Fuel efficiency in Table 30 refers to both the on road stock average under real driving conditions and the new fuel efficiency average. With the new technology CCTI characteristics supplied by the U.S. Department of Energy, Office of Transportation Technologies, the fuel efficiency of new heavy trucks in 2005 is 6.2 mpg.

Table 30. Comparison of Reference Case and CCTI Case Results

Projection	1997	2005		2010	
		Reference Case	CCTI Case	Reference Case	CCTI Case
New Heavy Truck Diesel Fuel Efficiency (Gasoline Equivalent Miles per Gallon)	5.58	5.80	6.17	5.99	6.40
Heavy Truck Diesel Fuel Stock Efficiency (Gasoline Equivalent Miles per Gallon)	5.10	5.41	5.58	5.58	5.80
Heavy Truck Diesel Fuel Consumption (Trillion Btu)	3,126	3,939	3,855	4,219	4,091
Transportation Petroleum Carbon Emissions (Million Metric Tons)	461.9	552.8	551.3	601.9	599.5

Source: Energy Information Administration, National Energy Modeling System runs CCTIB1.D033199H and CCTI3.D033199B.

The date of commercial availability (Table 28) is the first year that a technology is, or is expected to be offered by the manufacturers for possible purchase. Some technologies will never be utilized in certain vehicle applications regardless of cost. For example, a garbage truck may never be equipped with Advanced drag reduction technologies. Maximum potential market share (Table 28) is the highest percentage of trucks that could employ a given technology.

Improved Accessories has a larger market share than Improved Engine Efficiency in 2010, because of the earlier start date of 1998. By 2010, Improved Accessories will have penetrated the market for 12 years while Improved Engine Efficiency will have only been available for 4 years (Table 31). By 2020 the market share of Improved Engine Efficiency technologies is projected to reach 86 percent of new sales and Improved Accessories a 50 percent market share.

Table 31. Market Penetration of CCTI Proposal Technologies in the CCTI Analysis Case
(Percent)

Technology	2005	2010
Advanced Drag Reduction 2 (More Advanced)	0	0
Rolling Resistance	0	5
Accessories	10	36
Engine Efficiency	0	6

Source: Energy Information Administration, National Energy Modeling System runs CCTIB1.D033199H and CCTI3.D033199B.

In 2010 the stock fuel efficiency improvement in the CCTI case relative to the reference case is approximately 0.22 mpg, which results in a reduction of 128 trillion Btu of heavy truck diesel fuel, and a reduction of 2 million metric tons of carbon (Table 30). There are two factors which lead to these small reductions in fuel consumption and carbon emissions. Because of the late commercial availability dates (Table 29) two of the most promising technologies, Rolling Resistance and Engine efficiency, are limited in market penetration by 2010 (Table 31).

The second factor is the slow turnover rates in the stock of freight trucks. Even by 2020, the fuel economy of the truck stock in the reference case is 5.78 mpg compared to 6.45 mpg in the CCTI case. This difference has the effect of reducing heavy diesel fuel consumption from 4554 trillion Btu in the reference case to 4121 trillion Btu in the CCTI case, for a net fuel savings of 433 trillion Btu, and carbon emissions reductions of approximately 8 million metric tons.

Table 32 provides a summary of the fuel savings and carbon savings from implementing the light truck and heavy truck diesel technology proposals simultaneously.

Table 32. Total CCTI Light Truck and Heavy Truck Diesel Technology Summary, 2005 and 2010

Projection	2005	2010
Fuel Savings (Quadrillion Btu)	0.08	0.14
Carbon Emissions Reduction (Million Metric Tons)	1.7	2.8

Source: Energy Information Administration, National Energy Modeling System runs CCTIB1.D033199H and CCTITRN.D033199B.

Ethanol from Biomass

Ethanol is a renewable source of energy that historically has been primarily produced domestically. Since 1979, its use as a motor gasoline blending component has been encouraged through tax credits and subsidies, extending the supply of gasoline and thus reducing oil import requirements.[59] Gasoline can contain up to 10 percent ethanol without significantly reducing the performance of a standard gasoline vehicle engine. In addition, a new engine design that burns 85 percent ethanol and 15 percent gasoline has been developed, and its usage is projected to grow in the future.

Ethanol also contains oxygen and, with the onset of the oxygenated gasoline program in 1992 and the reformulated gasoline program in 1995, has been used to increase the oxygen content of gasoline, helping to lower carbon monoxide emissions. In 1997, 50,000 barrels per day of ethanol were blended into traditional and oxygenated gasoline, and another 32,000 barrels per day were blended in the production of reformulated gasoline.

Because it is a renewable fuel, ethanol can help reduce carbon dioxide emissions. Most of the ethanol currently used in gasoline blending is produced through a corn fermentation process. The carbon in the fuel does not increase net carbon emissions, because an equivalent amount of carbon will be absorbed from the atmosphere by the next rotation of crops. On the other hand, corn cultivation, fertilizer manufacture, and the distillation of alcohol are energy-intensive processes that generate significant greenhouse gas emissions.[60]

Ethanol can also be made from cellulose biomass, such as agricultural residues, switchgrass, and wood residues. Cellulose ethanol is an attractive alternative to corn ethanol for carbon reduction because switchgrass and woody crops require less cultivation and fertilizer than corn. In addition, solid byproducts from the processing of cellulose ethanol can be burned as fuel to cogenerate steam and electricity required to run the ethanol plant. Other advantages of cellulose ethanol include an inexpensive feedstock and possible wider regional distribution. It may be possible

[59]Ethanol blended into gasoline in 1997 represented 0.9 percent of net petroleum imports and 1.0 percent of motor gasoline product supplied.

[60]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Scenarios of U.S. Carbon Reductions, Potential Impacts of Energy Technologies by 2010 and Beyond* (Washington, DC, September 1997), pp. 5.30-5.31.

to locate the plants much closer to major refining and gasoline-consuming areas than is possible for corn-based ethanol, which is produced primarily in the Midwest.

Gasoline containing 10 percent ethanol currently receives a tax exemption of 5.4 cents per gallon, which translates into 54 cents per gallon for ethanol. This has a significant impact on the price of ethanol. In November 1998, for example, the subsidy lowered the price of ethanol by about half, from $1.08 per gallon to 54 cents per gallon, compared to the methyl tertiary butyl ether (MTBE) spot price of 62 cents per gallon.[61] The tax exemption is prorated for blends of less than 10 percent and also applies to ethanol used in the production of ethyl tertiary butyl ether (ETBE). In addition, some States provide tax incentives for the production of ethanol. The ethanol tax exemption has been extended several times since its introduction in 1979, most recently to 2007. Without the subsidy, ethanol's share of the market would likely be much smaller.[62] In the reference case for this analysis, extensions of the tax exemption are assumed through 2020.

The Office of Fuels Development (OFD) in DOE's Office of Transportation Technologies manages the National Biomass Ethanol Program, which encompasses research and development projects aimed at facilitating the evolution of a competitive domestic cellulosic biomass-to-ethanol production industry. OFD works with DOE national laboratories, other DOE organizations, the U.S. Department of Agriculture, universities, and corporations to develop the technological innovations needed to propel a biomass ethanol industry to market maturity. The major research and development programs focus on biomass feedstock development and ethanol conversion processes.

In 1998, the Nation's first biomass-to-ethanol demonstration plant opened in Jennings, Louisiana. DOE's industry partner, BC International, is converting a former grain-to-ethanol plant to a plant that uses agricultural residues as feedstock. In addition, BC International and the City of Gridley, California, are working with a biomass power company, DOE, and others in planning for another ethanol plant using local wood and rice straw as feedstocks. Another DOE partner, the Masada Resources Group, has selected a site in New York State for the final feasibility study of a solid waste recycling and ethanol production facility using municipal solid wastes. These projects are expected to result in commercial ethanol production plants in the 2001-2003 time frame.

The CCTI is not expected to have a large direct affect on the biomass ethanol program but will support the ongoing research and development efforts for this technology. Little additional funding for the ethanol program is expected, although biomass conversion may be included in a series of workshops sponsored under the auspices of the CCTI. The effect of the biomass ethanol program is already incorporated in the reference case. Although the impact of the research and development efforts on the market penetration of cellulose ethanol has not been directly modeled, the reference case assumes that the cost of producing ethanol from biomass will decline by 20 percent from current levels

[61] *Oxy-Fuel News Monthly Market Update* (December 21, 1998).

[62] Some State environmental agencies are considering restrictions on the use of MTBE. If the use of MTBE were restricted and oxygen content requirements for gasoline remained in place, the use of ethanol would likely increase considerably.

by 2020.[63] The cost decline reflects a learning function consistent with the one used in NEMS for the construction of new types of electricity generation plants.[64]

Ethanol production from corn is projected to increase slightly in the early years of the reference case projections, then fall back to near current levels by 2020. Cellulose ethanol, on the other hand, rises steadily through the forecast, reaching 57,000 barrels per day by 2010 (Table 33) and 127,000 barrels per day by 2020, thus surpassing the level of corn-produced ethanol. Ethanol from cellulose is a relatively new technology and cost reductions are expected to occur at a much faster pace than for corn ethanol, giving ethanol from biomass a greater impetus for growth. At the same time, because cellulose ethanol is a new industry, investments would be considered higher risk and involve greater uncertainty. For these reasons, a limit was placed on the rate of capacity growth. Cellulose ethanol production capacity is allowed to grow 50 million gallons per year (about 3,300 barrels per day) from 2001 to 2005. After 2005, if the economics are favorable, up to 250 million gallons per year (about 16,300 barrels per day) of capacity can be added. In those regions where State subsidies for ethanol production are provided in addition to the Federal tax exemption, the State subsidies induce capacity expansion for cellulose ethanol.[65] Carbon emissions reductions resulting from the displacement of gasoline by cellulose ethanol are projected at 0.3 million metric tons in 2005, 1.8 million metric tons in 2010, and 3.8 million metric tons in 2020.

Table 33. Ethanol Consumption and Resulting Carbon Emissions Reductions in the Reference Case, 1997, 2005, and 2010

Projection	1997	2005	2010
Ethanol Consumption (Thousand Barrels per Day)			
Corn-Based Ethanol	82	110	103
Cellulose Ethanol	0	8	57
Total	**82**	**118**	**160**
Carbon Emissions Reductions from Displacement of Gasoline by Cellulose Ethanol (Million Metric Tons)	0.0	0.3	1.8

Sources: **1997:** Energy Information Administration (EIA), *Petroleum Supply Annual 1997*, DOE/EIA-0340(97/1) (Washington, DC, June 1998). **Projections:** EIA, AEO99 National Energy Modeling System run AEO99B.D100198A.

The blending characteristics of ethanol may impede its future growth. As a motor gasoline blending component, ethanol has many attractive qualities. It is high in octane and contains no aromatics, benzene, or olefins. Ethanol, however, has a high Reid vapor pressure (Rvp) blending value and is water soluble. The high Rvp indicates a higher tendency for increased emissions of volatile organic compounds, which would hinder its use in summer gasoline

[63]This contrasts with the National Biomass Ethanol Program estimate of a 50-percent reduction by 2020.

[64]This learning function was subject to extensive review. See Energy Information Administration, *NEMS Component Design Report: Modeling Technology Penetration* (Washington, DC, March 1993).

[65]Motivated by a desire to develop new markets for agricultural products, States are assumed to provide the same subsidies for cellulose ethanol as for corn ethanol.

with tighter Rvp specification limits. Because of their water solubility, ethanol blends are not transported via pipeline. Consequently, ethanol use is restricted to splash blending at terminals near final points of gasoline distribution. In the reference case, the use of ethanol for splash blending is projected to remain close to current levels through 2010 (Table 34), increasing to 110,000 barrels per day by 2020.

Table 34. Projected Uses of Ethanol in the Reference Case, 1997, 2005, and 2010
(Thousand Barrels per Day)

Ethanol Use	1997	2005	2010
Direct Blending	82	56	77
ETBE	0	44	51
E85	0	19	32
Total	**82**	**118**	**160**

Sources: **1997:** Energy Information Administration (EIA), *Petroleum Supply Annual 1997*, DOE/EIA-0340(97/1) (Washington, DC, June 1998). **Projections:** EIA, AEO99 National Energy Modeling System run AEO99B.D100198A.

In addition to its direct use as a gasoline blending component, ethanol is used to produce another gasoline blending component, ethyl tertiary butyl ether (ETBE). ETBE is similar to methyl tertiary butyl ether (MTBE), a methanol-derived ether used extensively by refiners for oxygenated and reformulated gasoline. ETBE does not have the high Rvp and water solubility problems that plague ethanol. The cost of producing ETBE and the distance from major ethanol-producing areas to major refining centers has limited the use of ETBE, but it is expected to increase as gasoline specifications become tighter in the future. Ethanol use for ETBE production is projected to increase slowly but steadily in the reference case, to 50,000 barrels per day in 2010 and 60,000 barrels per day in 2020. Ethanol for E85 also increases throughout the forecast, rising to 30,000 barrels per day in 2010 and 50,000 barrels per day in 2020.

Electricity Generation

Fossil Technologies

The Department of Energy's Office of Fossil Energy (FE) has budgeted $37 million in 2000 for climate change funding (Table 35). This is a $13 million increase over the 1999 budget. The key areas of increase are for more efficient generating technologies (coal integrated combined-cycle, coal pressurized fluidized bed, fuel cells, gas turbines, and vision 21 power facilities ($9.7 million)) and carbon control and sequestration technologies ($3.3 million).

Table 35. Office of Fossil Energy CCTI Funding, 1999 and 2000
(Thousand Dollars)

Research Area	Fiscal Year 1999 Appropriation	Fiscal Year 2000 Request
Coal		
Advanced Clean/Efficient Power Systems		
Indirect Fired Cycle	$1,000	$1,000
High Efficiency - Integrated Gasification Combined-Cycle	$14,000	$16,250
High Efficiency - Pressurized Fluidized Bed		
Gas Stream Cleanup	0	$1,000
Pressurized Fluidized Bed Combustion	0	$400
Vision 21	0	$200
Advanced Research and Environmental Technology		
CO_2 Control/Sequestration	$5,800	$9,126
Advanced Research and Technology Development		
Coal Utilization Science	$2,000	$2,000
Material & Components	$1,000	$1,000
Gas		
Natural Gas Research		
Turbines		
Vision 21	0	$800
Fuel Cells	0	$5,000
Total	**$23,890**	**$36,776**

Source: U.S. Department of Energy, Office of Fossil Energy.

Efficient Electricity Generating Technologies

Background

The proposed 2000 budget calls for spending an additional $3.85 million above the 1999 budget on more efficient coal generating technologies. In total, the proposed budget for coal technology research and development in 2000 is slightly below the level for 1999—$122 million versus $123 million in 1999. However, where past efforts have primarily been focused on reducing SO_2, NO_x and particulate emissions from existing plants, future efforts are expected to focus on improving efficiency of the next generation of plants in order to lower their per kilowatthour carbon emissions. Technologies such as advanced gasification combined-cycle units, pressurized fluidized bed or gasification fuel cell units may lead to significant improvements in efficiency. In addition, FE has begun work on a new generation of plants referred to as Vision 21 facilities. As stated in the FE fiscal year 2000 budget request, "Vision 21 is an extension or continuation of ongoing R&D to lower the cost and dramatically improve the environmental performance and efficiency of coal plants that will lead to the deployment of a family of plants that converts a combination of feedstocks (e.g., coal, natural gas, biomass, opportunity fuels, petroleum residuals, wastes) to electricity, heat (e.g., steam), a suite of high-value products that may include synthesis gas, hydrogen, liquid fuels, chemicals, and by-products (e.g., sulfur and ash or slag)."

For gas technologies, the proposed 2000 FE CCTI budget includes $5.0 and $0.8 million on fuel cells and turbine systems, respectively. As described above for coal, these expenditures are focused on developing the new generation of plants—Vision 21 facilities.

Analysis

EIA has included the improvements in efficiency expected from coal technology R&D in recent analyses. In both the 1999 Annual Energy Outlook and the Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity reports, new advanced coal plants are expected to approach 47 percent efficiency. However, even with these improvements, over the next 10 to 15 years (without a carbon constraint), new plant additions are expected to be dominated by new gas plants. New natural gas-fired combustion turbines and combined cycle plants are, in most cases, the most economical options available when new plants are needed. New efficient coal plants are not expected to be added in significant numbers until after 2010 in the U.S.[66] These new plants gradually become economical as their construction costs decline and the gap between coal and gas prices widens.

However, in a carbon-constrained environment, new coal plants are unlikely to be very economically attractive over the next 20 years in the US without the development of an economic carbon sequestration technology. Currently coal-fired power plants produce over half of all of the electricity generated in the US and their average operating costs are under 2 cents per kilowatthour. Unfortunately, they also account for nearly 90 percent of the carbon produced in the generation sector. Even with fairly significant efficiency improvements the carbon intensity of new coal plants will far exceed that of other options—even other fossil ones (Table 36). As shown, existing coal plants produce over 2.5 times as much carbon per megawatthour of output when compared to a conventional combined-cycle gas-fired plant. Even when comparing an advanced coal plant to an advanced gas combined-cycle plant the ratio is expected to remain over 2 to 1.

[66]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).

Table 36. Carbon Emissions for Fossil Generating Technologies

Technology	Carbon Emissions		Efficiency (Percent) (Illustrative)
	Pounds per Million Btu Consumed	Pounds per Megawatthour Generated	
Coal Technologies			
Existing Coal	57	571	34
New Coal	57	519	38
Advanced Coal	57	418	47
Gas Technologies			
Conventional Turbine	32	336	32
Advanced Turbine	32	253	43
Existing Gas Steam	32	326	33
Conventional Combined-Cycle	32	222	49
Advanced Combined-Cycle	32	201	54
Fuel Cell	32	170	64

As a result, if a carbon cap is imposed, EIA analysis suggests that these newer more efficient coal plants will not be attractive in the U.S. through 2020. No new coal plants were built in any of the carbon reduction cases EIA has analyzed. U.S. power producers would be expected to rely on natural gas and, to a lesser extent, renewable fuels, to reduce their carbon emissions.[67] It is possible that new efficient coal plants may be attractive in foreign countries where natural gas and renewable resources are limited. In such countries, the cleaner, more efficient coal plants developed in the US may be helpful as part of an overall strategy in meeting their energy needs and reducing global emissions. In addition, in the longer run, if domestic gas and renewable resources are significantly more expensive than expected, these plants combined with sequestration technologies currently in the early stages of development may be important in the US as well.

With respect to new gas-fired technologies, EIA expects new power plant additions to be dominated by relatively efficient gas plants. In the most recent Annual Energy Outlook, new advanced gas generating plants are expected to reach nearly 54 percent efficient. As with the new generation of coal plants, Vision 21 gas plants are not expected to play much of a role in the time frame of the Kyoto Protocol. In the longer run they could be important, but their future may also depend on the development of economical carbon sequestration technologies if carbon reductions beyond those called for in the Kyoto Protocol are eventually needed.

[67]Energy Information Administration, *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*, SR/OIAF/98-03 (Washington, DC, October 1998).

Carbon Sequestration

While most carbon reduction option discussions focus on improving energy efficiency and increasing the use of low- or zero-carbon fuels, a third option is to remove the carbon emitted from a fossil power plant and permanently store it. Potential storage options include depleted oil and gas reservoirs or deep underground saline reservoirs, or the ocean. Norway is currently sequestering CO_2 in a saline aquifer below the North Sea, and CO_2 injection is currently used in about 70 sites worldwide for tertiary oil recovery. In addition, some hazardous wastes are currently disposed of in such a fashion, but their volumes are extremely small when compared to the amount of carbon (mostly as CO_2) that is produced by U.S. power plants. An alternative approach to sequestering carbon is to enhance natural biological processes that remove CO_2 from the atmosphere. Options in this category include forest management, increasing soil carbon content, and increasing ocean biomass productivity (with sequestration by sedimentation of bio-carbon). The fiscal year 2000 DOE coal technology research and development budget calls for spending approximately $9 million on carbon sequestration research and development.

If natural gas and/or renewable resources turn out to be much more expensive than expected, or if carbon reductions beyond the Kyoto protocol targets are required, technologies that remove and store carbon produced by fossil plants may be needed. At present, technologies for removing carbon from the flue gas of fossil power plants are very expensive. Most use a capital intensive monoethanolamine (MEA) solvent process that can more than double the cost of a conventional pulverized coal plant and the cost of the power it produces. It should be possible to lower these costs with newer combustion technologies such as coal gasification combined-cycle or fuel cell units and improved CO_2 capture approaches. However, much work is needed before these technologies will be economical. Further research is also needed to explore the economics and long term viability of CO_2 storage. Recent research suggests that the volumes that could be stored in some reservoirs are quite large, but more effort is needed to confirm this.

These technologies are not expected to contribute to reducing carbon emissions in the time frame of the Kyoto Protocol. If their economics can be improved significantly and long-term storage proves viable, these technologies could provide an additional reduction option in the post-2015 time period.

Renewable Technologies

Solar Photovoltaics

Costs for photovoltaics (PV) are declining. PV should become far more plentiful in off-grid and niche applications, especially where applications are highly valued and power alternatives are very expensive. Moreover, U.S. PV manufacturers and marketers are likely to find ready and growing markets for photovoltaic power outside the United States, especially where utility grids are weak or nonexistent.

Both domestically and abroad, where solar conditions are favorable, and where grid-connected or fossil-fueled generation is unavailable or too expensive, PV can provide environmentally welcome electric power for refrigeration, lighting, monitoring and measuring devices, pumps, communications, and other essential services. Nevertheless, PV remains orders of magnitude more expensive than electric utility supply for all but a few U.S. electric power applications.

On average, U.S. retail residential electricity prices are expected to remain well below 8 cents per kilowatthour ($1997) through 2020, though some believe peaking prices—such as on hot summer days—could exceed 15 cents per kilowatthour. However, costs for photovoltaic power today probably exceed 25 cents per kilowatthour in most applications. EIA estimates suggest that even in the most efficient (large-scale) wholesale applications, PV costs will likely exceed 10 cents per kilowatthour through 2020, when costs for more reliable natural-gas provided electricity remain 4 cents or below.

Consumer costs for PV power, especially if installed in very small units by retail commercial installers, or including energy storage systems (batteries), are likely to remain multiples of retail electricity rates. Therefore, where grid-supplied electricity is offered, it will almost always be much less expensive and far more reliable than PV alternatives. In EIA's opinion, even with notable cost reductions, it is highly unlikely that increased R&D will markedly change the relative economics of PV versus grid power in the near term. And, despite advances, PV is highly unlikely to become a significant component of overall U.S. electric power through 2020.

For thin-film photovoltaics, the DOE goal for 2000 is to have module efficiency reach 13 percent in prototype CIS or CdTe modules. Progress in thin-film PV is critical for future U.S. photovoltaics market success, both in achieving further significant drops in capital costs and in providing cost-effective PV performance. In addition to prototype performance, marked improvements will be needed in commercially available units. It is unlikely, however, that meeting targets will result in notable PV penetration of overall U.S. electricity markets.

Thin-film PV will require significant progress in order to make notable market penetration. The Department of Energy estimates current costs at around $9,000 per kilowatt, with goals of $5,300 per kilowatt by 2000, eventually dropping to $1,500 per kilowatt by 2010; capacity factors are reported at about 21 percent.[68] Given that current crystalline silicon technologies are reported to cost about $5,000 per kilowatt and have higher capacity factors than thin film, acceleration in progress for thin-film technologies is critical if they are to replace crystalline technologies and markedly expand U.S. and world PV applications. Nevertheless, if achieved, substantial progress in thin-film PV should accelerate world use of photovoltaics and improve U.S. opportunities in international markets, particularly in arid regions lacking utility-supplied power.

[68]Electric Power Research Institute and Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, *Renewable Energy Technology Characterizations*, EPRI TR-109496 (December 1997), pp. 4-23–4-24.

Solar Thermal

The DOE goal for dish/Stirling (concentrating) solar thermal energy systems for 2000 is to achieve 1,000 hours of unattended operation of a single dish/Stirling system during field testing. The dish/Stirling solar-electricity technology is attractive in providing clean renewable energy, in being modular, and in potentially offering essential electric power to distributed grid-connected or off-grid applications. Applications may be most promising outside the United States, such as for village power, where solar conditions are favorable and grid-connected power is unavailable. However, the dish/Stirling (concentrating solar) technology is far from commercial today, with test unit capital costs $10,000 to 20,000 per kilowatt. Further, dish/Stirling technologies have not yet been extensively tested or demonstrated. Goals for the technology include reducing capital costs to around $5,500 per kilowatt by 2000, $3,000 by 2005, and $1,600 by 2010, with capacity factors increasing from an assumed 13 percent today to 50 percent by 2000 and thereafter.[69]

The dish/Stirling technology faces large challenges in contributing to U.S. electricity supply before 2010. Meeting year 2000 goals, either in cost or performance, is unlikely, making the challenge of meeting later goals all the greater. Even if all goals are met, dish/Stirling will remain more expensive than almost all fossil and renewable energy alternatives. Moreover, its cost-effective applications are likely to be restricted to small, high-cost applications in the U.S. Southwest.

International prospects for dish/Stirling are better. Where solar conditions are favorable—such as in arid, developing regions—and where grid-connected power is unavailable, dish/Stirling may eventually compete successfully for rural essential electricity supply—including for both individual and small village service—against fossil fuels and wood use. It will also likely compete against other renewables, including wind and photovoltaics.

Biomass

The Department of Energy's Biomass Power Systems Program mission is to integrate sustainable biomass feedstock production with efficient biomass power generation and establish a cost-competitive power supply. As a net-zero carbon emitter, biomass consumption and the programs that support it can be viewed as completely supportive of the Climate Change Technology Initiative.

The budget request for fiscal year 2000 for Power Systems is $39 million and represents an increase of $7.5 million (24 percent) over the allocation for fiscal year 1999 (Table 37). There are three major energy technology thrust areas in the program: (1) co-firing biomass with fossil fuels, (2) small modular biomass power systems, and (3) advanced

---

[69]Electric Power Research Institute and Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, *Renewable Energy Technology Characterizations*, EPRI TR-109496 (December 1997), p. 5-57.

biomass gasification. Additional program elements are generally supportive of and integrated with these programs. These include thermochemical conversion research, energy crop development and the regional biomass program.

Table 37. Biomass Power Systems Budget

(Million Dollars)

Program	Projects	Goals, 2001-2006	Fiscal Year 1999 Appropriation	Fiscal Year 2000 Request
Cofiring with fossil fuels	Complete two current initiatives: - Willow with coal in New York - Switchgrass with coal in Iowa Complete three additional projects	 Generate 2 gigawatts Offset 4 x 10^6 tons of carbon	5.0	8.7
Small modular systems	Selection of projects from 10 design contracts	Complete test of 2-3 projects	2.0	4.0
Advanced gasification	Vermont wood-fired system Minnesota alfalfa gasifier	Sustained operation 2001 startup	16.0	19.5
Feedstock development	Research to improve grass yields Willow yield improvement Harvesting, etc. cost reduction Feedstock database development	2-3 high-yield clones 5,000 acres planted Complete database	2.3	3.1
Thermochemical conversion	Gas treatment/cleanup testing Alkali metals problem research NO_x emissions modeling Analytical equipment purchase	Install Vermont system	1.6	2.7
Other programs	Regional Biomass Program Various demonstration projects		1.3 3.4	1.0 0
Total			**31.5**	**39.0**

Source: Department of Energy Budget, web site www.cfo.doe.gov/budget/00budget/esrd/ee/renewabl.pdf, pp. 72-83.

The Department has several co-firing projects underway with power producers in a variety of stages. The two primary projects that are cost-shared are in the early stages and are planned for expansion with dedicated sources of biomass. The New York project goal is to have up to 600 acres of willow planted. The cofiring will be tested and the retrofit of two coal plants will be completed. In Iowa, the goal is to have up to 3,600 acres of switchgrass established by 2000 and be generating power in 2000. The program will also seek to expand the use of cofiring with additional cost-shared cofiring demonstrations. Data from retrofitting and testing at four established sites will be used to develop confidence in this method. Co-firing coal technology with biomass is discussed in Chapter 2.

The DOE program for small modular systems is directed at commercializing systems providing power in the 5 kilowatt to 5 megawatt size. They could be gasification or direct-fired systems. They are likely to be employed in an industrial application, possibly as a retrofit of existing biomass units. Funding is to be used for feasibility studies, demonstration units and developing full system integration, with a goal of testing 2-3 units. In its *Annual Energy*

Outlook 1999 (*AEO99*), EIA forecasts an expansion of biomass systems in the industrial sector, where cogeneration capacity increases from 5.5 gigawatts in 1997 to 7.4 gigawatts in 2020.

Advanced gasification development is focused on two projects that are part of the Biomass Power for Rural Development program. They constitute nearly half of the budget and are cost-shared with private investors. Program objectives include: 1) facilitate the transition from using residues to the use of dedicated crops, 2) support the expansion of large-scale crop production, and 3) develop a more environmentally benign source of power. The Vermont Gasifier project has been operating as a Gasifier only, and will add a combined cycle generation system and hot-gas clean up unit. The integrated system will be operated for 1000 hours and produce 8 to 12 megawatts of power. The Minnesota plant will use alfalfa stems and market the co-product leaves as animal feed. Construction of the 75-megawatt unit will begin in 2000 and startup is scheduled for 2001. The EIA analysis characterizes the biomass gasification technology in *AEO99* and tests penetration of it under the CCTI tax program, where a modest growth is shown (see Chapter 2).

The feedstock development program overlaps the other power systems programs in that this development is an important part of the economics of biomass utilization. The EIA includes biomass resources by way of supply curves, which could be affected by success in these programs. Since energy crops are not currently projected to be available on a large scale before 2010, these effects would not be felt until that time.

Thermochemical conversion programs are a set of longer-term research type projects. One is for research on gas cleanup options for both large and small gasification systems. This is a multi-year laboratory program that would support testing at the NREL Thermochemical User Facility. Another project is focused on minimizing problems from the high alkali metal content of many biomass fuels which can lead to fouling and slagging in boilers and furnaces. The research results are linked to the cofiring performance measures. A third project will evaluate the impact of restructuring on technology development by modeling their effects on NO_x emissions, and assess the need for incentives. Finally, some funding will be used for the purchase of analytical equipment as part of the laboratory program.

This set of programs are longer-term or part of the general support needed to improve the performance and economics of the various systems being evaluated, and are not directly evaluated by EIA.

Wind

The CCTI proposes accelerated R&D developing the next generation wind turbine, able to produce power at 2.5 cents per kilowatthour in good wind conditions by 2002.[70] Because of definition and measurement differences, the EIA equivalent unsubsidized 2002 target cost ($97) is about 4.5 cents, and the EIA equivalent 30-year levelized subsidized cost is about 3.8 cents.

First, the DOE 2.5 cent per kilowatthour estimate is net of the full 1.5-cent Federal production tax credit (PTC), adjusted to 1.7 cents when inflated to 1997 dollars. - assumed applicable for the first 10 years operation. The EIA 30-year levelized equivalent of this initial 10-year subsidy is about 1 cent. Second, DOE estimates exclude land costs, believed equivalent in EIA modeling to about 0.3 cents per kilowatthour.

In EIA's opinion, the technology costs of wind power continue to decline, and further progress is expected, in reduced component costs and in manufacturing economies of scale, and also via additional efficiencies in siting, constructing, and operating wind plants. Concurrent with rapidly growing industry experience, both in the United States and abroad, increased R&D may contribute materially to lowering wind power costs. However, current costs for installed wind *systems* appear to be considerably higher than expected; further, system costs may not be declining as rapidly as for turbine components. Moreover, it is not altogether clear where additional large savings will be realized or that increases in costs of some components (such as in reinforced towers or increased electronics) will not partially offset savings in others (like in simplified gearboxes). Unsubsidized levelized costs for new systems entering service today probably exceed 5 cents per kilowatthour. Therefore, reaching the 2.5 cent target by 2002 seems unlikely.

The DOE goal is for U.S. wind-powered generating capacity (using technologies developed by DOE) to increase from 1,859 megawatts on line in 1998 to 2,300 megawatts on line in 2000. EIA's *Annual Energy Outlook 1999* projects 2,800 megawatts of U.S. wind-powered generating capacity on line by 2000.[71]

Whereas in 1998, almost all U.S. wind capacity was in California, most of the additional capacity will be built outside California. By the end of 2000, large projects will also be operating in the Midwest, Southwest, and Northwest. The expansion occurs as a result of investments of more than $9 billion in wind power worldwide during the 1990s from public and private research and development efforts, in response to environmental concerns and in order to meet experimentation, testing, mandates, and other national, regional, local, and utility objectives. Worldwide, wind

[70]For understanding of the Department of Energy's wind technology expectations, EIA relied on the wind technology characterization of the Electric Power Research Institute (EPRI) U.S. Department of Energy joint publication, *Renewable Energy Technology Characterizations*, EPRI TR-109496 (December 1997), pp. 6-1, 6-31.

[71]Energy Information Administration, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998), p. 134.

generating capacity is increasing rapidly, estimated to have grown from around 2,000 megawatts in 1990 to about 9,600 megawatts in 1998.[72]

Geothermal

The mission of DOE's Geothermal Energy Program is to work with industry to establish geothermal energy as a sustainable, environmentally sound, economical source of energy. The proposed research and development program is directed at various approaches to reducing the overall costs of delivering power to consumers. The program has 4 main elements: reservoir technology, exploration, drilling technology, and energy conversion.

The reservoir technology program element is aimed at improving the understanding of reservoirs and exploring means to improve performance by means such as water reinjection. The expected result of this would be to extend field life so as to establish a more sustainable resource. EIA currently assumes some plant retirement as a result of enthalpy decline, and this activity could reduce or possibly eliminate such retirements. The budget proposal has this component increasing from $5.5 million to $8.0 million.

Exploration research is aimed at reduce the number of nonproductive wells drilled, through research on improved seismic methods. At present, the characterization of geothermal fields through seismic strategies remains a high-risk activity, leading to the need for more expensive exploratory drilling. The proposed budget would increase this component from $5.5 million to $7.0 million.

The drilling technology program will complete the testing of high-performance drill bits and other drilling technologies. The effort is aimed at reducing drilling costs, with a goal that they improve from being exponential with well depth to being linear with well depth. Because drilling can constitute up to half of the capital costs of a unit, this could greatly help in that regard. The budget element would increase from $5.0 million to $7.5 million.

The energy conversion program element has two principal parts. The first would initiate a cost-shared project to construct and test an 8-megawatt Kalina-cycle binary power plant. The plant would be more efficient and expand the low-temperature resource base. The second part of this program element is to continue research and development on small-scale modular power plants. Such plants could help maintain grid voltages and match loads and could also support mini-grids in remote applications. Funding for these projects has been proposed to increase from $6.0 million to $7.0 million. The overall geothermal energy budget proposal, increasing from $22.0 million to $29.5 million, is aimed at broad incremental cost improvements.

---

[72]C. Flavin, "A Force To Be Reckoned With, The Wind Power Market Boomed in 1998," *Renewable Energy World*, Vol. 2, No. 2 (March 1999), p. 17.

Hydropower

DOE is funding development of a new generation of hydropower turbines, reducing dangers to fish. In fiscal year 2000, DOE will complete pilot-scale testing of the new design, budgeting $7 million, up from $3.25 million appropriated in fiscal year 1999.

Conventional hydropower is by far the Nation's largest source of renewable energy for electricity generation, currently providing about 10 percent of all U.S. electricity and more than 80 percent of electricity from renewable energy sources. And hydro is the dominant source of electric power supply in some regions, particularly in the Northwest.

However, conflicts with hydropower are increasing, especially its dangers to fish populations. Prospects are growing for stalled or even declining U.S. hydroelectric output. Almost no new generating capacity is forecast through 2020; restrictions reducing output from existing hydroelectric facilities are increasing. Future increases in production from other renewables may be in large part offset or even eliminated by decreases in U.S. hydroelectric output, yielding a net decline in overall U.S. electric power production from renewable energy sources.

If conventional hydroelectric power is to retain or increase its contribution to U.S. electricity supply, methods of enhancing hydro's productivity must be found. Among the more attractive prospects for future hydro is introduction of safer, "fish friendly" hydroelectric turbines, presumably retrofitted into existing facilities as part of refurbishment and repowering activities.

EIA has not evaluated the prospects for success of DOE's hydroelectric turbine program; moreover, EIA cannot quantify the marginal economic benefits of the specific proposals in the CCTI. And any evaluation of the newer turbines would require additional information on likely turbine costs and performance, particularly the extent to which the safer turbines sacrifice (or gain) efficiency relative to existing technologies.

Nuclear Power

DOE's Office of Nuclear Energy plans to spend $5 million in 2000 on its Nuclear Energy Plant Optimization (NEPO) program. The goal of this program is "reducing barriers to efficient and safe operation—increasing plant capacity from 71 percent in 1997 to 85 percent in 2010 and addressing issues associated with plant aging." If successful it is hoped that this program will increase the number of nuclear plants that seek license renewal at the end of their current operating lives. In turn, this would reduce the need for new fossil-fired capacity and the increased carbon emissions that might be associated with it.

Without license renewal a large number of existing nuclear plants will reach the end of their current operating licenses by 2020. In EIA's latest analysis, the *Annual Energy Outlook 1999* (*AEO99*), just over one-fourth of the existing nuclear capacity is expected to be retired by 2010 and over half by 2020. These plants are expected to retire rather than relicense because the costs of their continued operation exceed the costs of power from other sources. In recent years, several nuclear plants have retired before license expiration when faced with the need to make large capital expenditures.

EIA has incorporated similar capacity factor assumptions in recent analyses. In fact, in the *AEO99* the capacity factor for nuclear plants is projected to be slightly over 85 percent in 2010. With respect to how much capacity might retire rather than relicense (or retire early), it is impossible to predict when and if other plants might face the need for expensive maintenance or upgrades as has occurred in the plants that have retired in recent years. In the *AEO99* EIA did look at alternative assumptions about these costs. The impact on carbon could be important, especially in the years after 2010. In the case where lower costs are assumed, carbon emissions are 11 million metric tons lower in 2010 and 31 million metric tons lower in 2020, relative to the reference case.

Other Energy-Related Research

Hydrogen Fuels

DOE will accelerate research on low-cost hydrogen production and storage, prerequisites to the widespread use of hydrogen as a fuel. A hydrogen-fueled economy would have many environmental benefits over the current fossil based system. The chief byproduct of the combustion of hydrogen is water. Hydrogen is very flexible and could be used in mobile as well as stationary applications. Interest in hydrogen as a fuel grew during the energy crises of the 1970s. At this time, it was believed that fossil fuel prices would continue to grow for the foreseeable future. At the same time, new nuclear plants were expected to be "too cheap to meter." The prospect of using new nuclear plants to produce hydrogen for use in mobile and stationary sources looked very promising under these circumstances.

The conditions described above have not materialized. As a result, there are several major hurdles that must be overcome before a hydrogen fueled economy could become a reality. These major hurdles involve improving the economics of hydrogen production, fuel distribution and handling, and storage systems. In addition, there is concern about technologies for handling and storing hydrogen safely. Today, the cost of these activities far exceeds the cost of fossil fuel alternatives. As a result, it is unlikely that increased use of hydrogen as a fuel will contribute significantly to efforts to reduce US carbon emissions over the next 10 to 20 years. As stated in the Hydrogen Program Overview prepared by Sandia National Labs, "Unfortunately, the widespread use of hydrogen energy is not currently feasible because of economic and technological barriers."[73] However, if these barriers can be overcome the long-run benefits could be quite large.

Currently most of the hydrogen used in industrial processes is produced using natural gas through a steam reforming process. In the most economical large plants hydrogen can be produced for $7 to $8 per million Btu. This does not compare well to the direct combustion of natural gas which sells for $2.20 to $2.30 per million Btu at the wellhead. In addition, because natural gas is used in its production it is not carbon free. It is possible to produce hydrogen using electricity (produced from renewables to eliminate carbon) and water but this process is even more expensive—around $30 per million Btu. New production processes such as photobiological and photoelectrochemical are being considered, but they are in the very early stages of research and development.

Similar economic hurdles exist in hydrogen storage systems. Again as stated in the Hydrogen Program Overview prepared by Sandia National Labs, "Current storage methods are too expensive and do not met the performance requirements of the various applications. This is especially true for hydrogen's potential use as a transportation fuel, where there is a need for high energy density—energy content per unit of space—and lightweight mobile storage." This is a significant hurdle because hydrogen has a very low energy density at normal temperature and pressure conditions. As a result, mobile fuel tanks will have to operate at very high pressure—perhaps as much as 2000 to 2500 pounds per square inch or more. Current systems that can handle such pressures are large and heavy. Researchers are now testing the use of new materials (lightweight graphite), but more work is needed.

In the long run, post-2020, hydrogen could be a very important source of energy in the US. Lower cost production processes combined with low cost renewable electricity offers the option of a carbon free energy sector. However, as described above it is unlikely that increased use of hydrogen as a fuel will contribute significantly to reducing anthropogenic carbon emissions over the next 10 to 20 years.

High-Temperature Superconductivity

DOE supports industry-led projects to capitalize on recent breakthroughs in superconducting wire technology, aimed at developing devices such as advanced motors, power cables, and transformers. These technologies would allow more electricity to reach the consumer without an increase in fossil fuel input.

The use of superconductive materials in electric power applications would provide an opportunity to reduce losses and the associated fuel use and emissions that go with them. Unfortunately, prior to the mid-1980s these materials had to be cooled to temperatures approaching absolute zero. This situation changed with the discovery of so-called high temperature superconductive materials in the late 1980s. These discoveries fundamentally changed the

[73]National Renewable Energy Laboratory, *Hydrogen Program Overview*, DOE/GO-10095-088, DE94011827 (February 1995).

economics of the technology. Prior to this change, low temperature materials had to be cooled to below -400°F in order for their superconductive properties to be realized. New materials discovered in the late-1980s displayed superconductive properties at higher temperatures, approaching -300°F. In recent years materials with superconductive properties at temperatures near -200°F have been developed. While to most people -300 to -200°F is still exceedingly cold, it is much less expensive to reach this temperature than the temperatures required for low temperature superconductors. Low temperature superconductors require the use of liquid helium, which is very expensive, while high temperature superconductors can use relatively inexpensive liquid nitrogen.

However, even with the advances that have been made since the late-1980s, significant technological and economic challenges must be overcome before their use will be wide spread. In addition, the losses that occur in the electrical coils in conventional motors and generators are quite small, often 5 percent or less, so the potential savings in fuel and emissions by the introduction of superconducting coils are not large. The costs of super conductive materials are still quite high. As stated in the Superconductivity Program Overview, "Materials used to produce high-temperature superconducting wire are inherently difficult to process into usable forms for electric power applications. This situation is the opposite of that for typical metallic electrical conductors, such as copper. And this fact presents processing obstacles that must be overcome to manufacture devices that can actually be used in electric power system applications."[74] The cost reductions required for them to be competitive are quite large. Again, from the program overview, "the cost of long-length, high-temperature superconducting wire needs to be reduced by 10 to 100 times to be competitive with other technologies."[75] It is possible that high temperature superconductive materials could eventually lead to lower electricity losses and, thereby, contribute to reducing US carbon Over the next 10 to 20 years they may find their way in to certain high value applications, but it is unlikely that they will play a significant role in US efforts to comply with the Kyoto Protocol.

Conclusion

The availability, costs, and operating characteristics of new energy technologies are highly uncertain. Although research and development funding can accelerate the pace of technology improvement, many of the programs in CCTI may have more significant impact beyond 2010 or even beyond the analysis horizon of 2020. In part, this is due to complexity of some of the technologies. However, the technologies, once developed, are subject to the same economic evaluation and stock turnover process as the existing technologies. Voluntary programs and similar initiatives may encourage the penetration of newer, more efficient technologies, but the true, incremental impacts of these programs as they have affected historical penetration are difficult to assess.

[74]National Renewable Energy Laboratory, *Superconductivity Program Overview*, DOE/GO-10095-012, DE95000204 (February 1995).
[75]National Renewable Energy Laboratory, *Superconductivity Program Overview*, DOE/GO-10095-012, DE95000204 (February 1995).

4. Energy-Efficient Appliances and Equipment

Introduction

A portion of the $273 million included in the CCTI proposed investment package for building technology is for acceleration of the lighting and energy efficiency standards program.[76] Energy use in buildings may be affected by the acceleration of updates to NAECA standards[77] for residential-style equipment such as heat pumps and central air conditioners, and for fluorescent lamp ballasts. Updates to EPACT standards[78] for commercial equipment may also affect energy use.

In 1987, Congress passed the National Appliance Energy Conservation Act (NAECA), which gave the U.S. Department of Energy (DOE) legal authority to promulgate minimum efficiency requirements for 13 classes of consumer products. The Energy Policy Act of 1992 (EPACT) expanded the coverage to include certain commercial building equipment. The law also mandated that DOE revise and update standards through time, as technologies and economic conditions changed. From 1988 to 1998, DOE was active in establishing and updating standards for the consumer products it was assigned to evaluate. Table 38 shows the products and years in which standards were either established or revised . This table includes the most recent revisions to the standards for room air conditioners and refrigerators/freezers which take effect in 2000 and 2001, respectively.

[76]"President Clinton's FY 2000 Climate Change Budget," p. 6, and "Report to Congress on Federal Climate Change Expenditures," p. 11.
[77]Standards authorized by the National Appliance Energy Conservation Act of 1987.
[78]Standards mandated by the National Energy Policy Act of 1992.

Table 38. Effective Dates of Appliance Efficiency Standards, 1988-2001

Technology	1988	1990	1992	1993	1994	1995	2000	2001
Clothes dryers	X				X			
Clothes washers	X				X			
Dishwashers	X				X			
Refrigerators and freezers		X		X				X
Kitchen ranges and ovens		X						
Room air conditioners		X					X	
Direct heating equipment		X						
Fluorescent lamp ballasts		X						
Water heaters		X						
Pool heaters		X						
Central air conditioners and heat pumps			X					
Furnaces-Central (more than 45,000 Btu per hour)			X					
Furnaces-Small (less than 45,000 Btu per hour)			X					
Furnaces-Mobile home		X						
Boilers			X					
Fluorescent lamps, 8 foot					X			
Fluorescent lamps, 2 and 4 foot (U tube)						X		

Sources: Energy Information Administration, *Annual Energy Outlook 1998*, DOE/EIA-0383(98) (Washington, DC, December 1997), and *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998).

The standards setting process is by no means trivial. Once a product class is determined, detailed engineering, economic, and manufacturer impact analyses are performed over a many-month period. Once the analyses are completed and made available to the public, an Advanced Notice of Proposed Rulemaking (ANOPR) is published. Approximately 8 months later, a Proposed Rule is published, with the Final Rule published in approximately another 8 months.[79] After the Final Rule is published, there is usually a two to three year lead time for the standard to take effect. Over the next two years, DOE plans to publish final rules for four product class revisions under its NAECA authority. These include central air conditioners, water heaters, ballasts, and clothes washers.

To estimate the potential impact of accelerating the standards-setting process, the timetable and levels used in the American Council for an Energy-Efficient Economy's *Approaching the Kyoto Targets: Five Key Strategies for the U.S.* is applied in the NEMS residential and commercial modules.[80] The efficiency levels and timetable presented generally appear feasible, assuming the process operates smoothly. Given the uncertainty surrounding the effective dates of

[79]The time line discussed here is the one given for central air conditioners by DOE's Office of Codes and Standards.
[80]American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the United States* (Washington DC, August 1998).

appliance efficiency standards, EIA includes only the standards that have been officially promulgated by the Department of Energy in its baseline forecast. Although the standards presented here are in no way related to the specific funding levels in the CCTI proposal, the analysis illustrates the effects that further standards may have on levels of energy use and carbon emissions. As with the tax incentive proposals, model results were obtained with and without the accelerated standards to gauge the projected impacts on the energy use and carbon emissions attributable to buildings. The analysis only considers the residential and commercial sector energy and emission effects, without considering any possible effects on energy prices or the economy. Table 39 details the efficiency level and effective date of the standard for each appliance considered.

Table 39. Proposal for Possible Accelerated Minimum Efficiency Standards Affecting Buildings

Technology	Current Standard	Proposed Standard	Proposed Effective Date
Clothes washers	0.82 MEF	1.40 MEF	2006
Air-source heat pump	6.8 HSPF 10.0 SEER	8.0 HSPF 13.0 SEER	2005
Central air conditioner	10.0 SEER	13.0 SEER	2005
Room air conditioner	9.7 EER	11.0 EER	2006
Electric water heater	0.86 EF	0.93 EF	2003
Gas water heater	0.54 EF	0.60 EF	2003
Refrigerator	496 kWh	397 kWh	2007
Dishwasher	0.48 EF	0.62 EF	2005
Furnaces (oil and gas)	0.78 AFUE	0.80 AFUE	2007
Commercial packaged A/C[a]	8.9 EER	10.3 EER	2005
Fluorescent ballasts	Energy efficient magnetic	Electronic	2003

[a]Effective date changed from that given in source reference. Timetable adjusted from 2001 to 2005 for Commercial packaged A/C based on current priority and stage in the rulemaking process.
[b]A small percentage of magnetic ballasts are retained after the electronic ballast standard is assumed to take effect. This represents exceptions to the standard granted due to electronic ballast frequencies interfering with the performance of other electronic equipment.
Source: American Council for an Energy Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the U.S.* (Washington, DC, August 1998).

Analysis Results

Table 40 presents projected results comparing the effects of the accelerated standards described above to reference case results without the accelerated standards. The values provided do not represent an analysis of the specific funding levels in the CCTI proposal, but present the potential effects of an accelerated standards program.

Table 40. Comparison of Results: Accelerated Standards Process

Variable	1997	2005		2010	
		Reference	CCTI Case	Reference	CCTI Case
Delivered Energy Use (Trillion Btu)	18,551	19,899	19,870	20,783	20,639
Carbon Emissions (Million Metric Tons)	522.2	582.5	581.4	613.6	608.4
Energy Bill Savings (Million 1998 Dollars)	—	—	431.3	—	2,333.5

Source: Energy Information Administration, National Energy Modeling System runs BLDCCTI.D031999B and BLDCCTI.D031999E.

Efficiency standards are projected to have more effect on energy consumption and carbon emissions than the CCTI tax incentives or the voluntary programs discussed previously. Minimum efficiency standards apply to all purchase decisions involving the affected technology. Given the levels assumed in this study, it is projected that 144 trillion Btu (0.7 percent) of energy can be saved by 2010 which translates into 5.2 million metric tons (0.9 percent) of carbon by 2010. Once set, standards continue to affect purchase decisions and energy use as new buildings continue to be built and worn out equipment is replaced. The longer an efficiency standard is in place, the greater the percentage of appliances in use that meet the standard and the greater the benefit in terms of energy and carbon savings compared to a reference case without the standard in place. By 2020 the accelerated standards case results in projected energy use that is 273 trillion Btu lower and carbon emissions that are 9.4 million metric tons lower than the reference case, providing residential and commercial consumers over $4 billion in energy bill savings.

Appendix A

Letters from the Committee on Science

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE

SUITE 2320 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
TTY: (202) 226-4410
http://www.house.gov/science/welcome.htm

December 16, 1998

The Honorable Jay E. Hakes
Administrator
Energy Information Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Dr. Hakes:

We appreciate the study that you did for us on analyzing the impact of the Kyoto Protocol on the U.S. energy system and the economy. The purpose of this letter is to request that the Energy Information Administration undertake a second study that analyzes the impact of specific policies on the reduction of carbon emissions and their impact on U.S. energy use and prices. Again, we are particularly interested in the 2008-2012 time frame, but the impact beyond this period is also important. The policies we would like you to evaluate should include tax incentives, new equipment standards, and the earlier introduction of new technologies. We are also interested in your evaluation of an earlier start date than 2005 (e.g., 2000), and incorporating whatever regulations the Environmental Protection Agency has specified for particulates.

As with the previous study, our staffs will be happy to work with you. In the next few months, we will provide the policies we want you to examine. We would appreciate the results of your analysis by this fall. Thank you, in advance, for your assistance and for the unbiased and reliable energy analysis that your agency produces.

Sincerely,

Jim Sensenbrenner
F. JAMES SENSENBRENNER, JR.
Chairman

George E. Brown Jr.
GEORGE E. BROWN, JR.
Ranking Minority Member

F. JAMES SENSENBRENNER, JR., Wisconsin, CHAIRMAN

GEORGE E. BROWN, JR., California
Ranking Minority Member

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE

SUITE 2320 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
TTY: (202) 226-4410
http://www.house.gov/science/welcome.htm

March 2, 1999

The Honorable Jay E. Hakes
Administrator
Energy Information Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Dr. Hakes:

On December 16, 1998, we formally requested that the Energy Information Administration undertake a study to analyze the impact of specific policies on reducing carbon emissions. The purpose of this letter is to ask you to analyze the impact of the President's Climate Change Technology Initiative, as defined for the 2000 budget, on reducing carbon emissions from the levels forecast in the *Annual Energy Outlook 1999* reference case. Also, in our previous letter we asked you to evaluate an earlier start date than 2005, which was the first year that the price signal was passed to consumers in your study of the Kyoto Protocol that you conducted at our request. We would like you to use a start date of 2000 and compare the annual and cumulative carbon price for complying with the Protocol for 3 of the cases you considered in the earlier study (24% above, 9% above, and 7% below 1990 levels) with the later start date of 2005.

We would appreciate these analyses in the next few months and may request further analyses as we evaluate other policies that the Administration is contemplating. Our staff will continue to work with your staff on any questions you may have relating to this request.

Sincerely,

Jim Sensenbrenner

F. JAMES SENSENBRENNER, JR.
Chairman

George E. Brown, Jr.

GEORGE E. BROWN, JR.
Ranking Minority Member

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

OFFICE OF
AIR AND RADIATION

TO: Mary J. Hutzler
Energy Information Administration

FROM: Skip Laitner
EPA Office of Atmospheric Programs

SUBJECT: Comments on the EIA April 2, 1999 Draft Analysis of the Climate Change Technology Initiative (CCTI)

DATE: April 5, 1999

Thank you for the opportunity to comment on the draft EIA study, "Analysis of the Climate Change Technology Initiative." As your April 2 cover memorandum indicates, EIA will be finalizing the analysis for the hearing to be convened on April 14 by Chairman James Sensenbrenner of the U.S. House of Representatives Committee on Science.

Consistent with previous communications on this analysis, our assessment continues to find the analysis to be incomplete. Although it is my understanding that EIA is still working on Chapter 3 (discussing Research and Development issues), the analysis is largely an evaluation of the tax incentives' portion of the CCTI, but not of the R&D proposals nor the other deployment programs contained within that initiative. This is a significantly limiting factor in the report. Moreover, as we shall see discussed below, the CCTI is one but one element that complements the many other aspects of the Administration's overall climate plan. These include credit for early action, industry consultations, expanded federal energy management programs, and electric utility restructuring.

As it is now written, the draft EIA report excludes or mischaracterizes a number of programs that are critical to the success of CCTI. Neither is there any mention of ancillary benefits such as lower NOx and SO2 emissions, enhanced productivity benefits, strengthened international security, or improved energy security. Yet, all of these have been well-documented in the literature.

The EIA report adopts a very conservative stance in the evaluation of the Administration's climate initiative. Moreover, the NEMS model may not be the appropriate tool to adapt for this review. Yet, even with all of the conservative assumptions made within EIA's analytical framework, it is worth noting the numbers imply a cost of carbon that is approximately \$20-\$25 per ton over a 20-year period.

Comment on the Review Process

The EPA team that reviewed the EIA analysis has raised an important concern about the process EIA used to obtain agency input. As Appendix A of the report documents, the House Science Committee originally advised EIA of their request for an analysis of the CCTI on December 16,1998; and again on March 2, 1999. Yet, EPA only learned of the analysis on March 25, 1999. Had EIA informed the appropriate agencies involved with CCTI — notably DOE, EPA, Commerce, USDA, and HUD — then a much more meaningful analysis could have been completed. As the EIA review process now stands, however, it appears as though EIA staff may be substituting their own judgment of program impacts for the judgment of the many program managers who are actually doing the work to reduce greenhouse gas emissions. This apparent oversight can be corrected by working with the agencies to provide a full range of estimates about the impacts not only of the CCTI, but also about the mix of other programs and policies that form an important part of the President's overall climate action plan.

The Role of Technology Policy to Secure Cost-Effective Reductions in Greenhouse Gas Emissions

As in the March 31, 1999 EPA memo providing earlier comments on the EIA report, our own analysis continues to underscore the importance of investigating a range of scenarios in which programs and policies are used to actively promote the adoption of new efficiency and low carbon supply technologies. Past reviews of programs either now in place, or now under consideration — including such programs as the Climate Change Action Plan (CCAP) and the Administration's Climate Change Technology Initiative — indicate a significant opportunity for cost-effective carbon reductions. For example, a recent analysis by the American Council for an Energy-Efficient Economy indicates that just five major policy strategies could obtain more than 310 million metric tons (MtC) of carbon reductions by 2010.[1]

The opportunity to positively impact the nation's economy was further underscored in a recent study undertaken by the EPA Office of Atmospheric Programs. As you know, we recently completed an analysis of a high-efficiency/low-carbon scenario (HELC) for the United States. The integrated technology scenario analysis used the National Energy Modeling System (NEMS) as modified for EPA by the Lawrence Berkeley National Laboratory (LBNL). The HELC scenario is driven largely by the technology assumptions that parallel those found in the so-called "Five-Lab" study released by the U.S. Department

1. American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the United States*, Washington, DC, August 1998.

of Energy in late 1997.[2] The EPA/LBNL analysis showed that by 2010, it may be possible to obtain carbon reductions of nearly 300 MtC at a net energy bill savings to the United States.[3]

A second study undertaken by the EPA Office of Atmospheric Programs and the Argonne National Laboratory (ANL), further documents the idea that a policy-driven, technology-led investment strategy can secure substantial domestic reductions of greenhouse gas emissions at a net positive impact on the U.S. economy. The analysis used ANL's All Modular Industry Growth Assessment (AMIGA) system, a computable general equilibrium model, to represent the effects of a successful expansion of well-designed energy efficiency policies and programs.[4] The results from numerical simulations show that investments in cost-effective energy efficiency technologies will tend to increase overall economic activity by about 0.6 percent within the United States (in the year 2010). This positive result stems from a net reduction in energy expenditures made possible by the investment in cost-effective energy efficient technologies. Perhaps just as important, economy-wide employment is also shown to increase in 2010, albeit by a very small 37,000 jobs.[5] I cite these studies because I believe it is important to provide a larger context in which to provide both Congress and members of the public with the information needed to assess the opportunity of programs like the CCTI and others.

Mischaracterizations of Agency Programs

Without a more thorough consultation with program managers who are responsible for many of the CCTI activities, it is inevitable that a number of programs can be easily mischaracterized. In the case of the ENERGY STAR programs, for example, the EIA analysis quantifies only two of the products scheduled for introduction into the ENERGY STAR product line. But EPA and DOE have plans to introduce a large number of labeling programs in 1999 and 2000. These include residential light bulbs (compact fluorescent lamps), television converter boxes (cable, satellite, etc.), ventilation fans, telephone products,

---

2. Interlaboratory Working Group, *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond*, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, Washington, DC, September 1997.

3. See, Jonathan G. Koomey. R. Cooper Richey, Skip Laitner, Robert J. Markel, and Chris Marnay, *Technology and Greenhouse Gas Emissions: an Integrated Scenario Analysis Using the LBNL-NEMS Model*, EPA 430-R-98-021, U.S. Environmental Protection Agency, Washington, DC, September 1998. (Note: this study is available in PDF format at *http://enduse.lbl.gov/Projects/GHGcosts.html.*)

4. Further documentation of the AMIGA model can be obtained by contacting Dr. Donald Hanson, Argonne National Laboratory, Argonne, IL, (630) 252-5061.

5. Skip Laitner, Kathleen Hogan, and Donald Hanson, *Technology & Greenhouse Gas Emissions: An Integrated Analysis of Policies that Increase Investments in Cost Effective Energy-Efficient Technologies*, presented at the Electric Utilities Environment Conference on Science, Regulations & Impacts of SO2, CO2, O3, NOX & Mercury in Tucson, Arizona, January 11, 1999.

visicoolers (self-service chilled drink machines), ceiling fans, ducts, battery chargeable products, internal power supplies, ice cube makers, water coolers, wall pack transformers, traffic lights, and water heaters. For the EPA-managed products alone, ENERGY STAR product labeling is projected to save more than 20 MtC by 2010.[6] These figures are not reflected in the EIA analysis, nor do they include planned new products.

As another example, on page 23 the writeup of the million solar roofs initiative (MSRI) states that: "Approximately 400,000 units are planned to be constructed under the program from 2000 to 2006, the period of the solar tax incentives. Any such units receiving the receiving the tax credits during this interval would be unintended beneficiaries, because the MSR program pre-dates the CCTI tax incentives. . . ." This statement misses the point of the MSRI program. EIA seems to be suggesting that the incremental benefit of the tax credit is negligible when compared to plans for the existing MSRI activities. What EIA may misunderstand, however, is that MSRI is a flagship program of the CCTI, not an isolated strategy beyond the scope of the CCTI.[7]

As another example, the draft report significantly mischaracterizes the National Research Council (NRC) prognosis for the Partnership for a New Generation of Vehicles (PNGV) program as reflected in the NRC Fourth Report. The effect is to be overly pessimistic with respect to the potential success of PNGV and to undermine the very increase in resources that the NRC report promotes. For example: The EIA report states on page 57, "unless the PNGV program receives significantly more funding, its goals most likely will not be met." However, the NRC report actually states on page 5 that, "some of the year 2000 vehicle attributes will probably fall short of the established targets, *but the preproduction prototypes are expected to meet the targets by 2004.*"[emphasis added.][8]

Use of the NEMS Model

On page 6, the statement is made to suggest that "NEMS can directly analyze the penetration of new technologies and the impacts of changes in the characteristics of technologies." In many cases, this is a misleading statement in the context of this analysis.

First, the NEMS model is not very responsive to changes in prices. This can be seen in the high carbon taxes necessary to achieve GHG stabilization in their Kyoto analysis. This lack

---

6. Carrie A. Webber and Richard E. Brown, "Savings Potential of Energy Star Voluntary Labeling Programs," Lawrence Berkeley National Laboratory, Berkeley, CA, August 1998.

7. For more information on MSRI, contact EPA's Solar Coordinator, Kurt Johnson, at (202) 260-7026. Or contact Peter Dreyfuss, the National Million Solar Roofs Coordinator at DOE, at (202) 586-8779.

8. Background materials on PNGV and related programs can be obtained from EPA's Office of Mobile Sources in Ann Arbor Michigan, by contacting either Jeff Alson at (734) 214-4536, or Jim McCargar at (734) 214-4244.

of responsiveness implies that consumers will not alter their behavior because of subsidies or investments for energy-efficient technologies. Higher, more plausible elasticities within the model — especially in the context of a major technology shift such as envisioned by the Administration's climate plan, including CCTI — would imply a greater level of emission reductions and lower costs.

One of the major goals of the CCTI is to make energy-saving technology cheaper and more widely available. A significant motivation behind this is the desire to capture increasing economies of scale and scope in these technologies — for example, increasing the level of production of hybrid vehicles is expected to lower the per unit cost which will encourage more people to buy them. The NEMS model does not do a good job of estimating these economies of scale. This, in turn, leads to an underestimate of the cost savings associated with the combination of the tax incentives, the R&D funding, and the market transformation programs operated by both DOE and EPA. This feature of the NEMS model is shown on page 38 where, in the reference case, at production volumes of 2,500 hybrid vehicles per year, they cost $10,000 more than gasoline vehicles, while at production volumes of 25,000 hybrids they still cost $7,000 more.

Second, the AEO 1999 reference forecast used to contrast the effects of CCTI is based on very low energy prices, especially for petroleum. This model assumption resulted in significant changes in energy use compared to the AEO 1998 forecast. The past few months have seen significant increases in the price of oil, calling this assumption into question. The assumption by the AEO forecast of continued low oil prices in the future will serve to limit estimates of consumer adoption of energy-efficient technologies.

Third, the NEMS model includes impacts only within the U.S. economy. It cannot estimate the international effect of various policies. In fact, the CCTI would encourage the development of technologies that potentially could be exported to the rest of the world. In addition, any energy savings could translate into improved international competitiveness for many U.S. businesses.

Fourth, the fact that the tax credits in the CCTI are in effect for just a few years only increases the probability that the NEMS model will fail to predict behavior changes in response to those credits. Alternative scenarios in which the investments were extended into the future would be a useful sensitivity analysis of the model.

Fifth, NEMS is not able to model CHP correctly since it allows the introduction of new CHP systems largely as a function of new steam demand resulting from industrial growth. There is no real ability to replace industrial steam boilers with more efficient cogeneration systems does not currently exist.

Sixth, the entire focus of the analysis that is being prepared for Congress is based only on energy-related carbon emissions. This is understandable since carbon dioxide emissions account for about 85 percent of the total U.S. greenhouse gas emissions (weighted by global warming potential). But an analysis by researchers in the Netherlands[9] and elsewhere suggest that cost-effective reductions in non-carbon greenhouse gases — including methane, nitrous oxide, and the so-called "F-gases" (HFCs, PFCs, and SF_6) — can make a significant contribution to the achievement of the Kyoto target for the United States. The Netherlands paper concludes, for example, that in the year 2010 about 40 percent of the required emission reduction for the EU-15 can be realized by these gases at a reasonably low cost.

NEMS does not have the capacity to model these so-called "other gases." Yet, mapping out the potential reductions from the other gases would provide an important contribution to the Administration's overall climate plan. The EPA Methane and Utilities Branch, for example, has completed preliminary cost curves which suggest that, at $50 per metric tonne of carbon, about 65 million metric tones of carbon equivalent (MtC) of methane reductions would be available by 2010.[10]

Finally, models such as NEMS embrace standard economic theories of the firm that stress profit maximization as the foundation for predicting behavior. Yet, statistical and case-study evidence continues to accumulate that real firms do not always act as required by standard theory. Rather, both consumers and businesses can be modeled as a network of information-processing agents that function within a network structure and that have limitations on the ability to process information on technology choices and environmental impact. This approach can be used to explain a number of features of technology diffusion that NEMS cannot adequately handle.[11]

The CCTI in Context

As we have stated in previous correspondence, it is premature to release the EIA analysis in its current format. Simply stated, it is incomplete. There are at least two reasons for this statement. First, an analysis of this type requires a more comprehensive approach for the overall analytical framework. Among other things, it ignores the larger part of the President's climate plan, including credit for early action, industry consultations, expanded federal energy management programs, and electric utility restructuring. It should be pointed out that this last

---

9. deJager (1998). D. deJager, C.A. Hendricks, H.A.M. Heijnes, and K. Blok, "Emission Reduction Potential and Costs for Non-CO_2 Greenhouse Gases in the EU-15," ECOFYS Energy and Environment, RK Utrecht, the Netherlands, 1998.

10. ICF Incorporated, "Costs of Reducing Methane Emissions in the United States: Preliminary Report," Methane and Utilities Branch, EPA Atmospheric Pollution Prevention Division, Washington, DC, July 31, 1998. See also, Reid Harvey, Methane and Utilities Branch, EPA Atmospheric Pollution Prevenetion · Division, "The Cost of Reducing Methane Emissions in the United States," a presentation to the Air and Waste Management Association, Washington, DC, October 13-15, 1998.

11. See, for example, Stephen J. DeCanio and William E. Watkins, "Information Processing and Organizational Structure," *Journal of Economic Behavior & Organization*, Volume 36 (1998), pages 275-294.

item alone (i.e., restructuring) is estimated to provide somewhere between 25-40 MtC of carbon reductions by 2010. The positive market impact of a more competitive electricity market on the development of Combined Heat and Power Systems may add to this total as discussed below.

As part of the Administration's overall climate action plan, the CCTI includes $1.8 billion per year in funding over the next few years. Even within the more limited review of the CCTI, the EIA analysis only concentrates on the $0.4 billion per year that is set aside for tax incentives. While there are difficulties associated with estimating the effects of increased funding for research and development on technology and energy savings, disregarding the effects of 80 percent of the CCTI funding is not appropriate. Additional comments on the opportunity for research and development (R&D) are discussed below.

Second, the report appears to provide only a point estimate of the possible benefits of the CCTI programs and policies. Moreover, these benefits appear to focus only on the lower-end of a range of possible impacts. We suggest that it would be more helpful in policy deliberations if EIA were to include other ranges of credible program impacts (as provided by the program managers and their current business plans). This again relates to the concerns raised earlier about the process of completing this evaluation.

An example may help illustrate the importance of adopting a systems perspective within this type of analysis. In buildings, for instance, we can tote up the incremental costs of insulation, windows and other improvements to determine the overall cost of the "efficiency premium." But this approach may overlook the system benefits that are likely to result at a substantially lower cost of improvement. Such improvements include the use of smaller heating, ventilation and air conditioning (HVAC) systems, and the use of fewer on-site materials in constructing a new home as the result of an improved building design. Similarly, reviewing only the tax aspect of a series of complementary programs and policies may overlook the benefits of changing markets that result from other synergistic aspects of the Administration's full approach to climate change policies. More on this below.

Returning to the critical and direct linkage between the PNGV program and the tax credit, EIA chose not to analyze the impacts of the CCTI budget increase for PNGV (presumably, in part, because their model does not extrapolate R&D programs to policy or market behavior). But in so doing, EIA also failed to adequately consider PNGV technology, timing, and cost targets in the analysis of the related tax credit. The tax credit is one policy specifically designed to help commercialize the very technologies developed through PNGV, which is solely an R&D program. The whole point of PNGV is to "shift the paradigm" by developing cost-effective technologies that, when commercialized, would motivate environmental and competitiveness benefits. The tax credit is a necessary complement to PNGV, helping to overcome manufacturer and consumer barriers to commercializing those new technologies. (See also comments below related to the EIA tax credit analysis.)

Most of the CCTI expenditures are aimed at fostering long-term dynamic technological change. Therefore, over the long-run, the CCTI together with the additional components of the Administration's climate plan, moves the economy toward a more energy-efficient development path. By conducting separate analyses only on the components of the CCTI, the savings from energy-efficient technologies may be understated. This is because the efficiency savings are not allowed to influence sectors of the economy outside of the specific one affected by the tax incentive.

The analysis does not incorporate an expectation of future policies like the Kyoto Protocol to limit GHG emissions (although the letter from Sensenbrenner on March 2, 1999 indicates that this may be included in the future). Policies to limit emissions in the future should encourage the early adoption of energy-efficient technologies, due to expected future high energy prices. This would, in turn, increase the impact of the CCTI.

Again, both the EIA and the NEMS analysis include only the U.S. economy and cannot estimate the international effect of various climate policies. The CCTI would encourage the development of technologies that could potentially be exported to the rest of the world. In addition, any energy savings could translate into improved international competitiveness for U.S. businesses.

The EIA analysis examines only the role of the federal government within the CCTI. Yet, states and local governments are actively seeking opportunities to save money, improve air quality (and other environmental conditions), and reduce overhead costs wherever possible. To date, 60 percent of the states have calculated their greenhouse gas emissions. Of that, twenty-five states have initiated state action plans to examine greenhouse gas emissions (GHG) reduction opportunities. To illustrate the potential contribution by states, the results from just five state studies show that if they implemented all of the recommendations in their plans, they could collectively reduce GHG emissions by 34 MtC and save over $600 million/year. Alternatively, to show the results the of actions now being taken, the localities that are participating in the Cities for Climate Protection Campaign reduced their GHG emissions by 1.3 MtC in 1998 (in addition to the 1738 tons NOx, 168 tons VOC, 3446 tons SOx, and 1431 tons of CO and $25.7 million in energy and fuel cost savings).[12]

There appears to be one odd statement on page 9 of the draft report, commenting that "uncertainty on future fuel prices" does not favor investments in energy savings. This may hold true if the current prices are high, and if future prices are expected to go lower. But if prices are expected to rise from where they are today, then investments in energy-saving technology can be used to offset the uncertainty about those future price increases.

---

12. See, International Council for Local Environmental Initiatives (ICLEI), "U.S. Communities Acting to Protect the Climate: 1988 Achievements of ICLEI's Cities for Climate Protection-U.S." For more information on the state action plans reports. Contact, Katherine Sibold, Team Leader, EPA State and Local Climate Change Program, at (202) 260-4314.

Research and Development

Research and Development (R&D) is a critical part of the Administration's Climate Change Technology Initiative. And for good reason. Numerous studies show a very high private and social rate of return to investment in research and development (R&D) programs. Mansfield notes, for example, that "[d]ozens of economists working independently with quite different sorts of models and entirely different kinds of data have found that the social rate of return from industrial innovations and R&D has been very high, frequently 40 percent or more. This is a remarkable fact, and one that policy-makers should recognize."[13] DeCanio provides a table of almost two dozen studies showing an average social rate of return to R&D of 60 percent.[14] The Council of Economic Advisers (1994) reports estimated social rates of return on R&D range as high as 50 to 100 percent.[15]

CEA further suggests that the high rates of return are a strong indication that both firms and society as a whole are underinvesting in R&D. This point was brought home forcefully in a recent paper by Jones and Williams (1997).[16] Using a conservative estimate of the rate of return to R&D of about 30 percent, the authors conclude that optimal R&D investment is at least four times larger than actual investment.

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

In a paper commissioned by the EPA Office of Atmospheric Programs, Breger found that after 20 years, 0.6 Quads of energy could be saved for each $100 million of R&D devoted to

---

13. Edwin Mansfield, "Social Returns from R&D: Findings, Methods and Limitations," *Research Technology Management*, Volume 34, Number 6, November-December 1991.

14. Stephen J. DeCanio, "Review of Economic Effects of Global Climate Change Policies" (Memorandum to Everett M. Ehrlich), May 30, 1997.

15. Council of Economic Advisers, *Economic Report of the President*, Washington, DC, 1994.

16. Charles I. Jones and John C. Williams, "Measuring the Social Return to R&D," Stanford University, Stanford, CA, January 1997.

energy efficiency technologies.[17]

Yet, for all of the work indicating significant economic opportunity for energy and carbon-saving R&D, there appears to be an implied bias which suggests that energy-saving or carbon-saving technology — almost as a given — will provide only second level benefits compared to almost any other R&D investments (see, for example, Weyant and Olavson[18] and the comments on this paper by Laitner[19]). While there is an allegation that this may be true, there is no documentation of such an assertion. On the other hand, there are major studies that show very high returns from energy-related R&D. For example, Braid, et al, found that while only 24 percent of 609 inventions that received R&D support were developed to the point of producing a commercial product with actual market sales, 144 of these "successful" inventions, had generated $961 million (1994$) of sales through 1994. This was significantly greater than the DOE investment of $124 million (also through 1994). Carbon emissions were reduced by 1.4 MMT in 1994 as a result of three of those inventions.[20]

Geller, et al, reviewed seven case studies involving DOE-sponsored technology R&D. They concluded that, even if it is assumed that the technologies would have developed commercially in as little as five years later without federal support, the net benefit of federal involvement is roughly $50 billion on a taxpayer investment of $16 million.[21]

---

17. Dwayne S. Breger, "Energy R&D and Energy Savings: A Review of Literature and Data, and the Development of a Rule-of-Thumb" (unpublished manuscript prepared for the EPA Office of Atmospheric Programs), Lafayette College, Easton, PA, January 1997.

18. John Weyant and Thomas Olavson, "Induced Technological Change in Climate Policy Modeling," Working Paper 14.5, Energy Modeling Forum, Stanford University, Stanford, CA, April 1998.

19. Skip Laitner, "Comments on EMF Draft Working Paper 14.5, 'Induced Technological Change in Climate Policy Modeling,' by John Weyant and Thomas Olavson, April 1998," EPA Office of Atmospheric Programs, Washington, DC, August 1998.

20. Braid, R.B., et al, "The Energy-Related Inventions Program: A Continuation of Demonstrated Benefits to the Inventor Community," ORNL/CON-429, Oak Ridge National Laboratory, Oak Ridge, TN, 1996.

21. Geller, Howard, Jeffrey P. Harris, Mark D. Levine, and Arthur H. Rosenfeld, "The Role of Federal Research and Development in Advancing Energy Efficiency: A $50 billion Contribution to the Economy," *Annual Review of Energy*. Volume 12, pages 357-395, 1987.

Several points are worth repeating. First, as Jones and Williams have suggested, the evidence indicates that the present level of R&D spending is far from optimal. Second, even if it were known that the social rate of return to energy-efficiency R&D were lower than the return to some other kinds of R&D, it would still be justified to increase energy-efficiency R&D if: (1) the environmental benefits sufficiently augment the other economic benefits; or (2) it is not possible (perhaps for political reasons) to increase R&D in the other sectors. A social rate of return of 30 percent is still quite attractive, even if some other (unobtainable) opportunity offers 50 percent.

Assumptions within the Buildings Sector

In the discussion on tax incentives beginning on page 12, EIA asserts that the value and length of tax incentives will be insufficient to affect general consumer behavior toward energy efficiency or barriers to entry, and that they would not change the economics of the investment decision for consumers. We believe that this conclusion ignores growing evidence in the marketplace that targeted rebates or incentives, especially when coupled with aggressive consumer education campaigns, can (and do) affect consumer purchasing habits.

For instance, evidence from promotion of ENERGY STAR-compliant clothes washers in the Pacific Northwest demonstrated that an active public outreach and education campaign combined with a limited duration rebate of $75-150 (generally 10-20 percent of the total cost of a horizontal axis washer now on the market) increased the market share of this equipment from less than one percent to over eighteen percent over the period of one year. In addition, since the rebates were terminated in late 1998, the market share of horizontal axis washers has not dropped appreciably.[22]

Further, EIA's analysis comparing the cost premium for higher efficiency with the anticipated rebate provides an inaccurate assessment. First, EIA states that the tax credit is less than 10 - 20 percent of the cost of the technologies. Yet, the price *premium* for the highest efficiency air-source heat pump (9.0 HSPF/15.0 SEER) is quoted at only $1,200. When reduced by a $500 rebate, the tax credit covers 41 percent of the price *differential* in the first year. The rebate shown for the highest efficiency central air conditioner in Table 2 covers more than 50 percent of the price premium.

Finally, EIA's analysis does not account for how the combined effect of the tax credits and the reduced operating costs of higher efficiency equipment will affect consumer behavior. The evidence demonstrates that consumers will take operating costs into consideration when making purchasing decisions for long-lived and energy intensive equipment. For instance, *Consumer Reports* now regularly reports on the *total* cost of owning major appliances such

22. The source for this is the Northwest Energy Efficiency Alliance. A more complete reference can be provided upon request.

as refrigerators.[23]

To use an example from Table 2 in another way, let us compare a Central Air Conditioner at a SEER of 10.0 and 13.5. If we assume a 3.5-ton unit that operates at about 1,000 hours per year, at an average cost of $0.06/kWh for electricity, the more efficient unit would have an internal rate of return (before the tax credit) of about 10 percent over a 12-year life. But with a $250 tax credit, the IRR would increase to about 30 percent. The increase in return would have an important impact on overall consumer behavior. Such a change in behavior is not apparent when analysts compare the effects of a rebate only to the total first cost of a high efficiency appliance. One might choose to vary the assumptions by lowering the number of operating hours, or by allocating the tax credit in different ways within the benefit-cost analysis. But the point remains that when the rebate is applied against the incremental investment, the return can be sufficiently high to motivate businesses and consumers to act in favor of climate protection and their bottom-line.

While this simplified example reveals a different picture than portrayed in the EIA analysis, EPA has used the information based on the DOE-2 model as part of its ENERGY STAR HVAC Investor software. The purpose is to demonstrate that higher efficiency equipment usually costs less over its lifetime when energy costs are taken into consideration, *even absent* rebates, tax credits or other financial incentives. This software is currently being used by HVAC contractors, including Sears Home Central's sales force. However, because EIA's analysis only examines first cost issues when considering consumer behavior, it cannot effectively account for the combined effect of first cost incentives and life-cycle cost savings.[24]

On page 17, EIA states that it has used, among other software packages, the PEAR building simulation model. The use of this model is puzzling since PEAR was developed 10 years ago. However, there are more recent and accurate building simulation models available. It would have been more appropriate to use DOE-2 or a commercial application such as REM-RATE for this analysis.

Indeed, these newer building simulation models do account for orientation, infiltration and tighter duct work which EIA acknowledges that PEAR does not address. During a heating season in Chicago, infiltration and duct-loss can contribute to more than 60 percent of the energy lost. In addition, when builders do tighten the house envelope, builders can and do downsize the heating and cooling systems, another significant cost saving not considered by this analysis.

To indicate the importance of orientation, infiltration and tight duct work, EPA attempted to duplicate EIA's analysis in Table 5 for a 2-story, unheated basement, 2240 sq. ft home in Chicago, but also included these considerations. EPA's analysis indicates that the incremental

---

23. See, for example, *Consumer Reports*, January 1999.

24. More information on this program can be obtained from EPA's David Lee, Energy Star Homes Branch Chief, (202) 564-9131.

cost to improve its energy efficiency is conservatively $2,400, rather than $4,902 reported by EIA. Yet, an increasing amount of work indicates that taking a systems perspective may reduce initial capital costs even further. For example, a Mississippi Energy Demonstration Project showed there are "break points" in which the costs of the energy-efficiency improvements are balanced by the reductions in other construction costs.

These "break points" involve levels of energy efficiency that allow a specific component of a building to be downsized or deleted. Construction costs were actually lowered by improving the building envelope performance. This allowed the downsizing of mechanical equipment. Furthermore, the savings provided more than offset increased costs associated with controlled mechanical ventilation and source control of pollutants. This example demonstrates dramatic improvements in energy efficiency (50 percent reduction in energy use) while saving costs on construction (-$500/unit) compared to standard construction. More information on this program and "systems perspective" can be found at the Building Science Corporation.[25]

On page 20, EIA states that the penetration of energy-efficient homes is driven by the number of years it takes to achieve a positive cumulative cash flow. Given the potential for significantly overestimating the true cost for energy efficiency improvements, any market penetration analysis based on such a criterion should be reviewed with more recently developed models as noted above. However, the use of such a criterion should also be reexamined. Mortgage data indicates that the average homeowner holds a mortgage for six years. Such a time horizon could have an impact on homeowners' decisions to purchase energy efficient homes. In addition, published economic analysis indicates that energy efficient homes have increased market value relative to a similar but standard efficient home. A recent study indicates an increase of $10 to $25 in home value for every $1 reduction in annual utility bills.[26] If true, any criterion estimating market penetration should also consider asset value of the home upon resale. This is a set of complicated interactions that cannot be simply captured in a standalone analysis as put forth by EIA at this time.

On page 50, EIA discusses the potential impact of PATH. It is unclear how EIA performed this analysis. PATH is a new initiative that continues to evolve. As an evolving program, it is difficult for any external analysis, such as EIA's, to estimate its impact. For example, Path Goal #2 is to reduce energy usage in new homes by 50 percent. However, PATH has not yet defined energy usage. PATH could very well define energy usage as thermal envelope, HVAC, water heating and appliances. In many cases, appliances can contribute to 50 percent of the energy costs. However, EIA's analysis does not consider appliance costs, and therefore, may incorrectly state PATH's impact. Furthermore, another PATH goal is to reduce the cost of new homes by 20 percent. If such a goal were coupled with the energy efficiency goal, it is conceivable that energy efficiency could be improved with a reduction in first costs for such improvements. The eventual outcome for PATH is unclear, but there are several goals to that program that could work in tandem to accelerate the penetration of

25. See, http://www.buildingscience.com/buildamerica.html.

26. This was published in the *Appraisal Journal.* A full citation can be provided at a later time if desired.

energy efficient homes using EIA's criterion of positive cumulative cashflow. The EIA report should acknowledge such interactions.

Beginning on pages 83, EIA reviews the impact of appliance and residential equipment efficiency standards. To that extent they cite the ACEEE study, *Approaching the Kyoto Targets*[27], for a number of different residential models. However, EIA concludes that tighter efficiency standards will gain only 5 MtC by 2010. ACEEE, on the other hand, estimates for the same mix of appliances as shown in Table 39 a total impact of almost 17 MtC. This is a substantial difference in results when using largely the same performance criteria in EIA's own assessment. Unfortunately, the EIA analysis does not provide enough detail to resolve this issue.

Beginning on page 51, it again remains unclear what assumptions that EIA used to arrive at the AEO99 reference case electricity/carbon savings for the ENERGY STAR TV/VCR program, as shown in Table 23. These results differ from the Lawrence Berkeley National Laboratory projections, which estimate that by 2010, total emissions will be reduced by more than this for TVS, not including VCRs and other home electronics.[28]

These differences may be reflective of several developments in electronics manufacturing and ENERGY STAR Program structure which may not be included in EIA's reference case. First, since the introduction of the ENERGY STAR TV/VCR Program in 1998, many manufacturers (such as Sony Corporation) have chosen to "over-comply" by introducing televisions that use significantly less than the allowed 3 watts in standby mode. In fact, many the new models introduced by manufacturers such as Sony, Toshiba and Panasonic use less than one watt. In addition, the reference case may not account for the fact that the ENERGY STAR Program includes a Tier II specification to be effective in 2002. Early evidence from manufacturers suggests that a one-watt specification for ENERGY STAR-compliance may be both reasonable and cost-effective in this time frame. In fact, the 2003 Tier II specification for ENERGY STAR audio equipment and DVD equipment (which use essentially the same power supply designs as TVS and VCRs) is set at one watt, which argues that a similar specification is possible for TVS and VCRs. For these reasons, we believe the EIA figures may seriously underestimate the realistic impact of the ENERGY STAR TV and VCR programs on energy use and carbon emissions from this equipment.

We also believe that the reference to the split incentive problem with efficient vending machines omits a significant advance in program design which will give all participants a positive economic incentive to produce energy efficient vending machines. Specifically, the draft ENERGY STAR specification for vending machines would compel manufacturers to produce machines with more efficient electronic ballasts and T-8 lamps. Although this would

---

27. American Council for an Energy-Efficient Economy, *Approaching the Kyoto Targets: Five Key Strategies for the United States*, Washington, DC, August 1998.

28. For more information on this program, contact Scott Thigpen, EPA Branch Chief for the Energy Star Labeling Program, at (202) 564-9002.

raise the price of the machines to bottlers, they would recoup the additional costs due to the longer life of the lighting in the machines, thereby reducing the number of service trips needed over the life of the machine. (Bottlers generally provide the machines for free and profit from a percentage of the coin box receipts). EPA and the vending machine industry have calculated that bottlers should realize a payback of approximately two years for energy efficient machines using electronic ballasts and T-8 lamps. Customers, as always, realize immediate cost savings from reduced energy bills.

We are pleased to note that EIA now acknowledges, on page 52, that although the total life of a vending machine does average seven to ten years, this fails to account for the fact that machines are pulled from service every three to five years for refurbishing. This provides an opportunity to accelerate the stock turnover rate. Yet, without apparently talking to the EPA program manager about how the labeling agreement would operate, EIA maintains the same sentence as in the previous draft to suggest that "transforming the market may present quite a challenge." There does not seem to be a basis for this statement.

Again, as noted earlier, the report continues to quantify only two of the products scheduled for introduction into the ENERGY STAR product line. In 1999-2000, EPA and DOE plan to introduce labeling programs for residential light bulbs (compact fluorescent lamps), television converter boxes (cable, satellite, etc.), ventilation fans, telephone products, visicoolers (self-service chilled drink machines), ceiling fans, ducts, battery chargeable products, internal power supplies, ice cube makers, water coolers, wall pack transformers, traffic lights, and water heaters. For the EPA-managed products alone, ENERGY STAR product labeling is projected to save more than 20 MtC by 2010.[29] Although these figures not include planned new products, the ENERGY STAR staff can provide the necessary details to amplify the references on pages 51-52..

Combined Heat and Power

Although this latest version of the report has added more analysis to the section on Combined Heat and Power (CHP) Systems, EIA continues to maintain a number of pessimistic assumptions about technology costs and market penetration within the CHP analysis. While such assumptions may be appropriate for a lower-bound analysis, it does not provide either Congress or other policy makers with the full opportunity that might be captured through CCTI. For example, the report suggests that the large presence of free riders may overstate the benefit of CCTI with respect to development of CHP. Yet, it is equally valid to suggest that there may also be free drivers which encourage the development of CHP systems. There are other assumptions which may be overly pessimistic as well. This may be all the more so given DOE's recent CHP challenge to double CHP capacity by 2010 compared to baseline forecasts. EPA is fully supportive of that goal and is undertaking a number of initiatives to

---

29. Carrie A. Webber and Richard E. Brown, "Savings Potential of Energy Star Voluntary Labeling Programs," Lawrence Berkeley National Laboratory, Berkeley, CA, August 1998.

accelerate such investments.

Page 8 of the report continues to note that if CCTI encourages energy efficiency, the reduced demand for electricity may provide less opportunity for the electricity sector to invest in new technologies. But it continues to be equally valid to say that encouraging the development of the new generation of combined heat and power and distributed energy systems can result in greater competition that, in turn, may reduce the cost of conventional generation technologies. This point may be greatly reinforced as a result of the trends within electric utility restructuring.

The cost assumptions for key technologies may be unnecessarily high. This may be reflected in the dated references cited on the bottom of page 27. The report suggests that system costs may be in the range of $950/kW for large systems (>40 MW), increasing to as much as $1,600/kW for the smaller systems (<1 MW). On the other hand, a draft report by the American Council for an Energy-Efficient Economy (ACEEE) suggests a range of $500/kW for systems greater than 50 MW while smaller systems can approach $1,000/kW.[30]

Perhaps more important, it appears that EIA has consistently underestimated the market potential for investments in CHP systems. A recent EPA analysis concludes that by 2010, the total cost-effective industrial CHP capacity might be as much as 31 GWe by 2010 compared to a 1996 baseline.[31] The most recent EIA analysis indicated only a 6.0 GWe increase in that same time period.[32] In addition, a new study of district energy systems suggests that there may be another cost-effective potential of 19 GWe of capacity among the institutional and commercial building systems.[33] With new policies proposed by restructuring and other programs, including DOE's highly successful Advanced Turbine Systems program,[34] the chances of reaching this total 50 GWe goal seem quite possible. Yet, the analysis provided by EIA provides an entirely different picture.

An outgrowth of both the climate issue and an active partnership between DOE, EPA, and the Pulp and Paper industry may be the more rapid development of the black liquor

30. American Council for an Energy-Efficient Economy, *Combined Heat and Power: Capturing Wasted Energy*, Review Draft, Washington, DC, December 1998.

31. ICF Resources, Incorporated, *Combined Heat and Power in the Emerging Competitive Market*, prepared for the EPA Atmospheric Pollution Prevention Division, Washington DC, February 1999.

32. Energy Information Administration, *Annual Energy Outlook 1999*, U.S. Department of Energy Washington, DC, December 1998.

33. Mark Spurr, *District Energy Systems Integrated with Combined Heat and Power: Analysis of Environmental and Economic Benefits*, International District Energy Association, Washington, DC, March 1999.

34. For more information on the DOE program, contact Patricia Hoffman, Manager of the Advanced Turbines Systems, at (202) 586-6074.

gasification combined cycle technology for that industry. The industry's own statements suggest that with the right mix of regulatory flexibility from EPA, coupled with an R&D cost-share to commercially demonstrate the new technologies, as much as 16-30 GWe of new capacity could be installed in that industry within the period 2010 to 2020. The result of this synergistic momentum between the regulatory efforts and the R&D initiative is that carbon emissions may be reduced by 30 MtC or more from this single technology application.[35] This is the kind of synergy that cannot be captured by the research design now employed by EIA in its evaluation of the Climate Change Technology Initiative.

Transportation

The draft EIA analysis states on page 57, "The goal of a fuel-efficient midsized vehicle with a purchase price similar to that of a conventional gasoline vehicle most likely will not be met." The PNGV cost goal is *not* purchase price alone. Rather, the goal is about the purchase *and operating cost* equivalent to current vehicles when adjusted for performance and the total cost of ownership. The PNGV Fourth Report acknowledges that cost remains "a significant challenge," but in response simply exhorts the participants to continue to conduct in-depth cost analyses and to use the results to guide the progress of the work (see page 11 of the NRC report). Moreover, the PNGV budget increase proposed in CCTI is consistent with the NRC Fourth Report. In fact, the report points out that *not* to increase the budget threatens the international competitiveness of the U.S. auto industry.

The PNGV Fourth Report emphasizes the importance of a simultaneous solution to technical challenges of combustion, aftertreatment, and fuels; the draft EIA report cites specific hurdles in each area, without characterizing the successes and potential to develop a system that is both clean and efficient.

In the LDV tax credit section, the penetration rates of electric vehicles may be significantly overestimated, both in the reference and CCTI cases. The model numbers appear to be driven by CA/MA/NY regulatory requirements for Zero Emission Vehicles (ZEVs). At best, there is significant uncertainty in EV penetration given the very low production numbers at present (low 1000's for next several years), range limitations, and cost. CA itself recognizes the uncertainty, has previously rescinded their pre-2003 ZEV requirements, and is exploring other options (including partial ZEV credits for other low-emitting vehicle classes, like SULEVs).

Penetration rates of hybrids are significantly underestimated under the CCTI scenario. It's difficult to nail this down without delving into the model, but based on the narrative there are several likely causes:

---

35. Forest Products Industry, "Gasification Combined Cycle Initiative," an unpublished power point presentation given on July 10, 1998. For a more complete discussion of this technology, see also Larson, E. D., W. Yang, K. Iisa, E. W. Malcolm, G.W. McDonald, W.J. Frederick, T. G. Kreuz, and C. A. Brown, 1998, *A Cost-Benefit Assessment of Black Liquor Gasification/Combined Cycle Technology Integrated Into a Kraft Pulp Mill,* Prepared for the TAPPI International Chemical Recovery Conference, Tampa, FL.

- The primary driver seems to be incremental cost of ATVs, and these are too high for hybrids. Even in the high-volume case, hybrids are shown as a $7000 increment (while fuel cells are only $2000!!!).

- High incremental cost for hybrids reflects inappropriate decoupling from PNGV program (see also comment above); PNGV should be generating hybrids with roughly comparable consumer cost in the timeframe of the credit program. The effect of the credit should also be to pull ahead availability of all hybrids, but particularly PNGV hybrids (those eligible for the two-times and three-times efficiency improvement credits).

- Narrative cites a number of ATV negatives to explain low penetrations, but the explanations of these negatives apply almost exclusively to battery-powered systems -- most *do not* apply to gas or diesel hybrids. For example, higher per-mile driving costs and fuel availability cited do not apply to diesel or gasoline fuels, and probably not even to diesel-like or gasoline-like reformulations that might be used in advanced DI systems. Hybrids should not suffer at all in luggage volume, vehicle range, and top speed, and certainly should not require higher horsepower and larger engines (exactly the opposite!!!). All of these factors were cited to explain the low penetration rates. There is a chicken/egg problem with NEMs here -- to the extent that assumptions like the above get reflected in the equations or inputs governing consumer choice, the results will be inaccurate.

- The purpose of the tax credit is to help overcome perceived risk on the part of both the manufacturer and the consumer in trying a new technology. It is unclear to us how this fundamental element is modeled into NEMS. It cannot solely be a basic elasticity of price demand by consumers. Quantification of risk in this case is very difficult; at minimum, it makes inappropriate (and misleading) the high precision of the results displayed by the model. We simply do not know to four significant digits what the sales penetrations of hybrids will be in 2005; we would be lucky to nail two significant digits.

- The model apparently presumes no "launch effect" from the credit, which is contrary to the purpose as expressed in the previous bullet.

- The life-cycle cost benefit of fuel efficiency gains in the hybrid is apparently disregarded.

Important input presumptions are unclear. What fuel economies are assumed for the hybrids? How is it decided which vehicle classes get the credit-eligible improvements? In fact, CAFE should be a major driving force in such decisions, and CAFE is not even mentioned.

The model results show some apparent inconsistencies or inaccuracies. Total light vehicle sales from the model are shown as 13.5 million units, starting in 1997. Actual sales were at least $14.5 million vehicles in 1997 and even higher in 1998. Also, the reference (non- CCTI) case shows revenue impacts (e.g., for diesel-electric hybrids) amounting to tens of millions of dollars. How can this be? Another odd statement appears on page 35 of the draft analysis: if stricter EPA vehicle emissions standards are passed, EIA seems to suggest that this lower market penetration rates for hybrid vehicles and their associated carbon emissions reductions. It seems more appropriate to think that the hybrids would be more efficient and would more likely to enter the market.

Finally, there are several minor edits that are worth noting. On page 40, 3rd full paragraph: change *nitric* to *nitrogen*. On page 33, first line of table: *Chrysler* is now *DaimlerChrysler*. And on page 34, 2nd to last paragraph: *braking* should be *a typical braking event*.

Renewables

The write-up on page 23 says that "Niche markets with local incentives in place and electricity rates much higher than the national average could create a situation in the which the CCTI tax incentive would make solar technologies economically attractive; however, the proposed incentive is much less than would be required to spur the growth in sales needed to lower production costs significantly and prompt even greater adoption of the technology." Again, EIA apparently doesn't link the proposed tax incentive as part of the whole MSRI package. By design, it was not intended to be separate from it. By itself, the proposed tax incentive may insufficient to "make solar technologies economically attractive." However, the proposed tax incentives may succeed if they are combined with all of the other elements of the MSRI. To address this issue, the revised version of the EIA analysis could provide a number for the expected pollution prevention benefits of 400,000 new solar roofs by 2006.

Conclusion

The EIA evaluation of CCTI tends to underestimate the full potential of the Administration's proposal to accelerate the deployment of energy-efficient, low-carbon technologies. At the same time, it appears to minimize the role of technology policies in general. The good news in all of this is that it should be relatively straightforward to provide the balance needed to properly complete this assessment. If EIA can convene a working group of key agencies involved in the CCTI and other complementary initiatives, then we should be able to provide Congress and other policy makers with critical insights they need about the full range of opportunities associates with CCTI. Again, please let me know how we can be helpful in this regard.

cc: Robert Perciasepe, EPA/OAR
David Gardiner, EPA/OP
Paul Stolpman, EPA/OAP
Kathleen Hogan, EPA/APPD

Eric Petersen, DOE/EERE