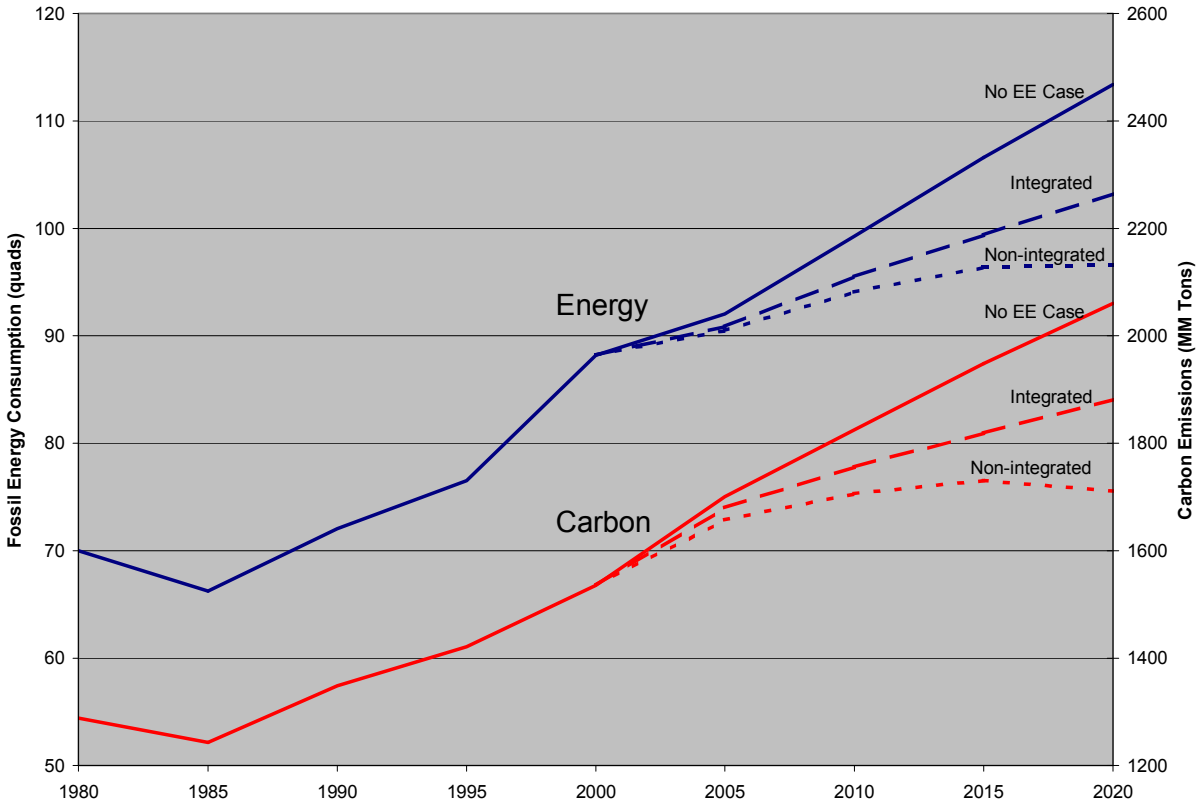
Projected Benefits of Federal Energy Efficiency and Renewable Energy Programs

FY 2003 – FY 2020



Prepared for the
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Contents

Introduction

This report summarizes the results of the Office of Energy Efficiency and Renewable Energy's (EERE) annual GPRA data call for Fiscal Year 2003. The Government Performance and Results Act of 1993 (GPRA), part of a world-wide performance measurement movement, is the U.S. federal government's response to concerns over limited federal resources and lack of agency accountability. GPRA requires federal agencies to develop a strategic plan, an annual performance plan, and an annual performance report. EERE's role in meeting these requirements is to provide information for the Department of Energy's strategic plan, performance plan, and performance report. The GPRA data call provides key information for these and other documents that communicate the benefits of EERE's programs as well as for internal management needs.

The current data collection effort has its roots EERE's 1993 Managing for Results activity. The purpose of Managing for Results was to collect benefit and cost information on EERE's programs to assist in funding decisions. In 1994 Managing for Results was renamed Quality Metrics. In 1995 near term (five year) performance measures (PM) were added to the FY1997 data collection to support the long term quality metrics and the process renamed the Quality Metrics/Performance Measures (QM/PM) data call. In 1997 the FY1999 data call attempted to improve the links between near-term performance measures and long-term quality metrics by requesting the technology and market penetration assumptions used in calculating long-term benefit estimates. The FY1999 data call was also the first used to meet GPRA requirements and was therefore renamed the GPRA Data Call. The FY2001 data call was streamlined by requesting that performance measurement information be placed directly in the budget. This included the development of "trended" performance measures, that is, performance measures that are quantitative, consistent from year to year, and could be displayed graphically.

Understanding EERE's data collection process first requires a general familiarity with EERE. The logic behind how EERE turns resources into benefits is presented in Figure 1. EERE collaborates with scientists, consumers, suppliers, industry officials, and other government organizations to perform research, develop new and improved products and processes, and provide policy, standards, technical tools and information that will accelerate and expand the adoption of energy efficient and renewable energy technologies. The adoption of these technologies will result in energy savings, increased use of alternative energy sources such as wind and solar, which means a cleaner, healthier environment, and less dependence on imported oil. The office is structured around the end-use sectors for which its technologies are developed: buildings, industry, and transportation, as well as the power sector and the federal government.

Data Collection, Review and Analysis Process

The annual process for obtaining projected benefits and performance measures occurs over approximately a nine month period, starting in April and ending in January. In April EERE's Office of Planning, Budget and Management (OPBM) began developing a data call or survey instrument. A draft instrument was distributed to EERE's five sectors for review, with comments incorporated into a final instrument that was distributed in September.[1] Sectors have about one month to submit their initial response to OPBM. After initial responses were received, about five planning unit responses were reviewed by external experts from October through December.[2] Planning unit responses were also used in an integrated analysis that accounts for the interaction effects across sector programs. The integrated analysis was completed in December. Final projected benefits and performance measures were then placed in the EERE budget request and will help form EERE's portion of the Department's Performance Plan and Performance Agreement with the President[3]. The survey instrument, sector non-integrated analyses, external review, and integrated analysis for FY2003 are described below.

Survey Instrument

The survey instrument developed for Fiscal Year 2003 requested the energy, environmental, and financial metrics shown in Table 1.

Table 1: Energy, environmental and financial metrics

Energy	Environmental	Financial
Total Primary Energy Displaced	Carbon Emissions Displaced	Energy Costs or Savings
Direct Electricity Displaced	CO Displaced	Non-Energy Costs or Savings
Direct Natural Gas Displaced	Other Greenhouse Emissions Displaced	Consumer Investment
Direct Petroleum Displaced	SO2 Displaced	EERE Expenditures
Direct Coal Displaced	NOx Displaced	Other Government Expenditures
Direct Biomass Displaced	PM10 Displaced	Private Sector Expenditures
Direct Energy from Feedstocks	VOCs Displaced	
Direct Energy from Wastes	Other Environmental Benefits	
Other Direct Energy		

Energy Metrics

The energy metric "total primary energy displaced" represents energy savings for efficiency programs and energy produced for renewable programs. It is based on the amount of direct energy displaced by fuel type (e.g., electricity, natural gas, petroleum, etc.) and heat rates for each fuel as outlined in the data call.

[1] See Appendix A for a copy of the FY 2003 survey instrument (data call).
[2] See Appendix C for a copy of ADL's review report.
[3] See Appendix B for a copy of planning unit responses and sector totals (reflecting changes made after ADL review)

Environmental Metrics

The environmental impacts are largely derived from the amount and type of energy displaced. Emission factors for each fuel type are provided in the data call. In some instances a portion of the environmental impacts may related to factors other than energy savings, such as process improvements in the industrial sector.

Financial Metrics

Financial metrics include a) inputs into planning unit activities, such as estimates of EERE expenditures, other government expenditures, and private sector expenditures for FY2003 through FY2007; b) intermediate outcomes such as consumer investment; and c) end outcomes such as energy cost savings, non-energy cost savings, and net economic benefit. Expenditure estimates are the best estimate of the planning units at the time the analysis was performed. Consumer investment is based on the incremental capital cost of a new technology and its market penetration. Energy cost savings are based on the amount of energy saved and energy prices. Non-energy cost savings included other savings such as productivity improvements. Net economic benefit is a combination of expenditures, consumer investment, energy cost savings, and non-energy cost savings.

Assumptions

The data call also requested assumptions that support the above calculations. Although no set format was requested, planning unit assumptions generally included market penetration estimates, technology performance levels, and technology cost. The Energy Information Administration's Annual Energy Outlook 2001 served as a baseline scenario for: a) energy prices; b) residential, commercial, industrial, transportation, and power sector technology projections; and c) energy consumption by industry. To ensure uniformity across programs, projections were provided for electricity heat rates and electricity carbon emission factors. These were derived by running a side case in the National Energy Modeling System (NEMS), which identified the changing electricity fuel mix given a reduction in electricity demand. Non-electricity heat rates and carbon emission factors were also provided.

Sector Non-integrated Analyses

The survey instrument was distributed in September 2001 to EERE's five sectors – Office of Building, State and Community Programs (BTS), Office of Industrial Technologies (OIT), Office of Power Technologies (OPT), Office of Transportation Technologies (OTT), and the Federal Energy Management Program (FEMP). Responses were received from 43 planning units across the five sectors. Each sector analyzed the impacts of its programs in a slightly different manner. A brief description of each analysis is provided below.

BTS developed characterizations for each of its programs. These include information on target market, market introduction, market penetration goal, consumer cost of conventional and BTS technology, and non-energy cost of conventional and BTS technology. These characterizations were used to develop inputs into the Building Energy Savings Estimation Tool (BESET) and the National Energy Modeling System (NEMS). Benefit estimates were generated using BESET (for non-equipment programs and equipment programs not easily characterized in NEMS) and NEMS (for equipment programs and technologies). For more information on BTS' methodology see *BTS Program Characterization Summaries - FY 2001 GPRA Metrics Effort* prepared by Donna Hostick (PNNL), September 10, 1999.

For its R&D programs, OIT used an experience-based market penetration model designed to estimate the national energy, economic and environmental impacts of innovative industrial technologies. For each R&D project a market penetration curve was selected from a handful of market penetration curves derived from historical analyses. Model runs for individual R&D projects were aggregated to obtain impact estimates for each planning unit. Typically, the projects analyzed represented 45 to 90 percent of the FY 2003 budget for the various planning units. Impacts of the technical and financial assistance planning units were assessed based on retrospective analysis of performance data accumulated over a period of years. Impact estimates assumed that continuation of the programs will result in beneficial impacts proportional to documented experience at historical budget levels. For more information on OIT's methodology see *GPRA 2001 Quality Metrics Methodology and Results: Office of Industrial Technologies* prepared by Energetics Incorporated for the Office of Industrial Technologies, April 20, 2000.

The OTT analysis included assumptions about the future costs and characteristics of alternative vehicles and fuels. Computer models that take into account the value that vehicle buyers place on various vehicle characteristics were used to estimate the market penetration of new vehicle technologies. Energy, environmental and financial impacts were derived from these market penetration estimates. Five analytical tools were used to calculate the various projected OTT program benefits: the Vehicle Size/Consumer Choice (VSCC) Model, the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) Model, the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, the Heavy Vehicle Market Penetration (HVMP) Model, and the Employment Spreadsheet Model (ESM). Outputs from some of these models become inputs to some of the others. For more information on OTT's methodology see *Program Analysis Methodology: Office of Transportation Technologies Quality Metrics 2001 Final Report* prepared by the OTT Analytic Team, February 23, 2000 available at http://www.ott.doe.gov/facts/program_impact.htm.

OPT used several different approaches for its two broad research areas, renewable energy technologies and electricity delivery. For the renewable technologies, the National Energy Modeling System (NEMS) was used to estimate future generating technology for the bulk power market. Changes were made to assumptions within NEMS, including the use of technology data from the EPRI/DOE *Renewable Energy Technology Characteristics*. A variety of technology-specific changes were also made, resulting in increased penetration of wind and geothermal technologies as compared to the AEO99 projections. The Green Power Market model was used to project the green power market size and allocate the various OPT technologies using an algorithm similar to that which is used by NEMS. The model performs the allocation using a

logit function which uses the various competing technologies' cost of energy to determine which will be chosen by the green power suppliers in a particular region. Customer-sited power projections were also performed for photovoltaics and biomass cogeneration. Different approaches were used for each of the electricity delivery programs (Renewable Energy Production Incentive, Solar Program Support (Competitive Solicitation), Hydrogen, Transmission Reliability, High Temperature Superconductivity, and Energy Storage). For more information on OPT's methodology see *Documentation for FY 2001 GPRA Metrics: Office of Power Technologies* prepared by Princeton Energy Resources International, February 2000.

The FEMP impacts assumed that Federal energy reduction goals (30% reduction by 2005 and 35% reduction by 2010) were going to be met.

External Review

For the past seven years EERE has had external experts review a portion of the planning unit responses. Five planning units were selected for the FY2003 review, based on whether they had not been previously reviewed, had large expected energy savings, were impacted by significant changes from last year's analysis (e.g., new initiatives), and had high visibility[4]. The five planning units reviewed for FY2003 include:

Office of Building Technology and State/Community Programs (BTS)
- Equipment, Materials and Tools (R&D component)

Office of Industrial Technologies (OIT)
- Forest Products – Black Liquor and Solid Biomass Gasification
- Industrial Materials for the Future

Office of Power Technologies (OPT)
- Wind

Office of Transportation Technology (OTT)
- Advanced Combustion Engine R&D

ADL experts worked with DOE staff to review the estimates and assumptions for each of the planning units. The external review is an interactive, iterative process between the individual planning unit managers and ADL experts, in each case leading to a consensus regarding the final submissions. The ADL review concentrated on three areas:

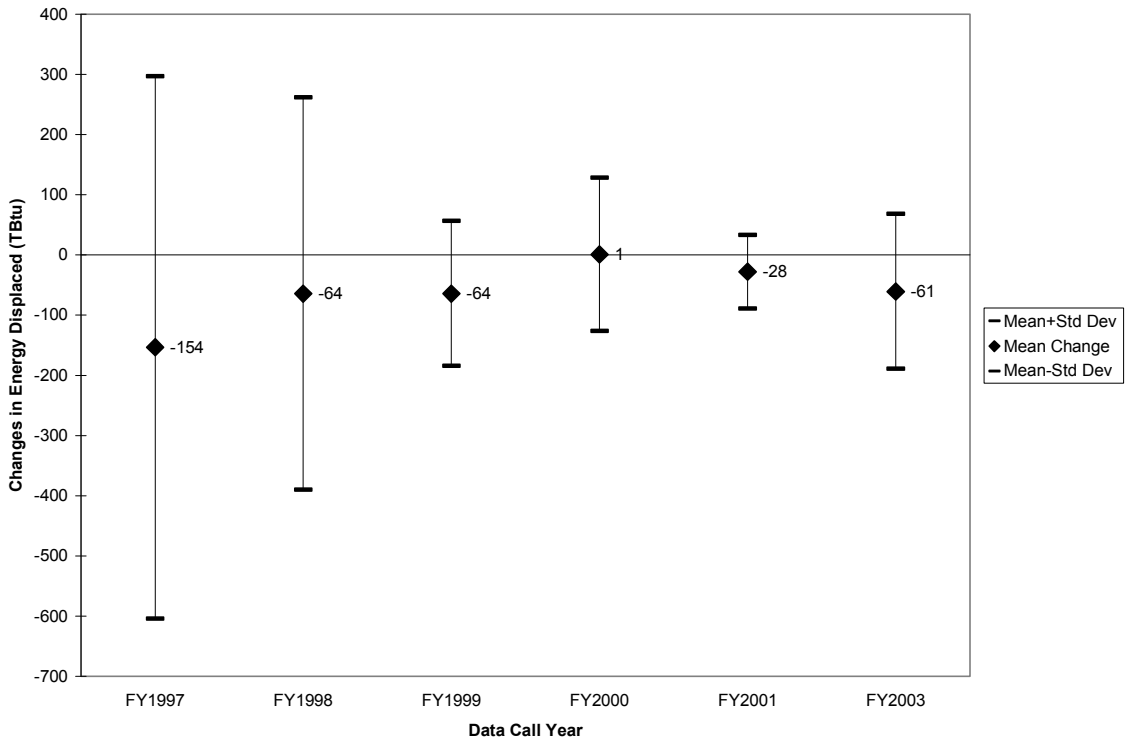
- The energy and carbon emissions savings of each technology projected for the years 2003 through 2030, which depend on estimates of market penetration, cost, and performance assumptions for each technology.

[4] See the Arthur D. Little report contained in Appendix B.

- The performance measurements of each Planning Unit, which include near-term goals and milestones for the next five years designed to achieve the market penetration, cost, and performance objectives underlying the energy savings metrics.

The discussions between ADL and the sectors resulted in four of the five planning units revising their impact estimates. A comparison of these revisions against those made in previous years shows that revisions are generally becoming smaller, likely indicating an improvement in EERE's estimates. Figure 2 shows that the average change to planning unit energy displacement figures after the external reviews have declined from -154 TBtu in FY to -61 TBtu in FY 2003. That is, the estimates were reduced by 154 TBtu in 1997 and only 61 TBtu in 2003. At the same time, the standard deviation of changes has narrowed from 450 TBtu in FY 1997 to 128 TBtu in FY 2003, reflecting a smaller range of changes across planning units.

Figure 2: Changes in Energy Displacement After External Reviews FY1997-2003



Integrated Analysis[5]

Once initial impact estimates were submitted by each sector, an "integrated set" of impact estimates were developed. The purpose of this assessment is to analyze EE's programs in a consistent economic framework and to account for the interactive effects among the various programs. Sector estimates of the savings for their programs cannot be simply summed to create a value for all of EE. There will be feedback and interactive effects resulting from (1) changes in energy prices resulting from lower energy consumption and (2) the interaction between programs affecting the mix of generation sources and those affecting the demand for electricity.

The National Energy Modeling System (NEMS) was used as the integrated model. The Annual Energy Outlook 1999 (AEO99) version was used as the starting point. Several changes were then made to the model to enhance its ability to represent the EE programs. The most significant changes were the addition of an endogenous building shell efficiency component and the inclusion of the Energy Information Administration's (EIA's) preliminary distributed generation and biomass cofiring structures. Significant parametric changes were made in some sectors, for example the behavioral assumptions for modeling alternative technology vehicles and various parameters affecting the expansion of renewable capacity in the electricity sector. The modified version of the model is referred to as NEMS-GPRA01.

The No EE Case. The baseline forecast, called the No EE Case, is a projection meant to represent the future U.S. energy system without the effect of continued EE programs. The idea is to remove any effects of EE programs that are already included in the AEO99 Reference Case in order to avoid double counting energy consumption reductions. As recommended by the various EE sector offices, the following modifications were made for the No EE Case. For the transportation sector, it was assumed that no advanced gasoline vehicles and no alternative fuel vehicles would be purchased except those mandated in California. Similarly, in the utility sector, it was assumed that there would be no new renewable capacity constructed except as part of state set-asides as represented in the AEO99. The No EE Case includes the modified shell efficiency structure and assumes that part of the shell efficiency improvement in the Residential sector in the AEO99 is attributable to EE programs. No changes were made to the industrial sector for the No EE Case. See the Integrated Modeling for GPRA 2001 report in Appendix D for the No EE Case projected energy consumption by sector and fuel.

Representation of EE Programs. After the No EE Case was established, the EE programs were represented in the various NEMS-GPRA01 modules. Each sector was treated separately to derive estimated energy savings without the interaction of the other sectors' programs[6]. Inputs for the programs were received from the sector offices and their contractors. To the maximum extent possible, the programs were represented through their impacts on technology characteristics, allowing NEMS-GPRA01 to project the market penetration and savings resulting from their development. In some cases, where the model had insufficient technology representation or the programs were of a market deployment rather than R&D nature, projections were based on the program office penetration estimates and NEMS-GPRA01 was used as an accounting tool. A major exception is the treatment of the industrial sector. The OIT programs

[5] The Integrated Analysis description draws heavily from OnLocation's Integrated Analysis report, which is contained in Appendix D.
[6] The modeling of the individual demand models was done using PC stand-alone versions of the module that speed the run time and facilitate data changes.

and technologies are very specialized and beyond the capability of the model to represent. For this sector energy savings were simply input.

Energy savings were estimated at the planning unit level for each sector, except for industry. In this step, the primary savings for electricity were computed using the marginal heat rates supplied in the GPRA Data Call. The use of these heat rates makes the savings directly comparable to the sectors' estimates. The integration with electricity is kept separate and is introduced as part of the integration effect. Preliminary comparison tables were shared with EE, and minor modeling adjustments were made based on their comments. The revised tables are shown in the sector descriptions below.

The full NEMS-GPRA01 model was then run for each of the sector office programs individually. In these scenarios the energy savings include the effect that a single sector's programs have on fuel consumption in the other sectors. For example, reductions in energy usage generally lead to lower energy prices, which may stimulate additional demand, both in the sector that is being analyzed and in all other sectors. The primary energy associated with reduced electricity generation is calculated endogenously within the electricity module. In addition, reductions in oil and gas use affect the energy required for oil and gas production, petroleum refining, and pipeline gas consumption.

Lastly, the full integrated model was run with all programs in all sectors to derive the Full EE Case. The total primary energy savings (fossil and nuclear savings because renewables are not included), carbon savings, and energy expenditures were then allocated to the individual sectors. Because the total savings were not equal to the sum of the individual sectors, they were allocated to the sectors based on the single-sector integrated savings estimates.

Projected Benefits 2005-2020

Planning units were asked to identify the impacts of their programs for the years 2001-2005, 2010, 2015, 2020, 2025, 2030. Estimates through 2020 are described below. Program impact metrics were divided into three areas reflecting the energy, environmental, and financial benefits of EERE programs. A list of the metrics associated with each area is contained in Table 1. Definitions for each may be found in the data call instrument provided in Appendix A.

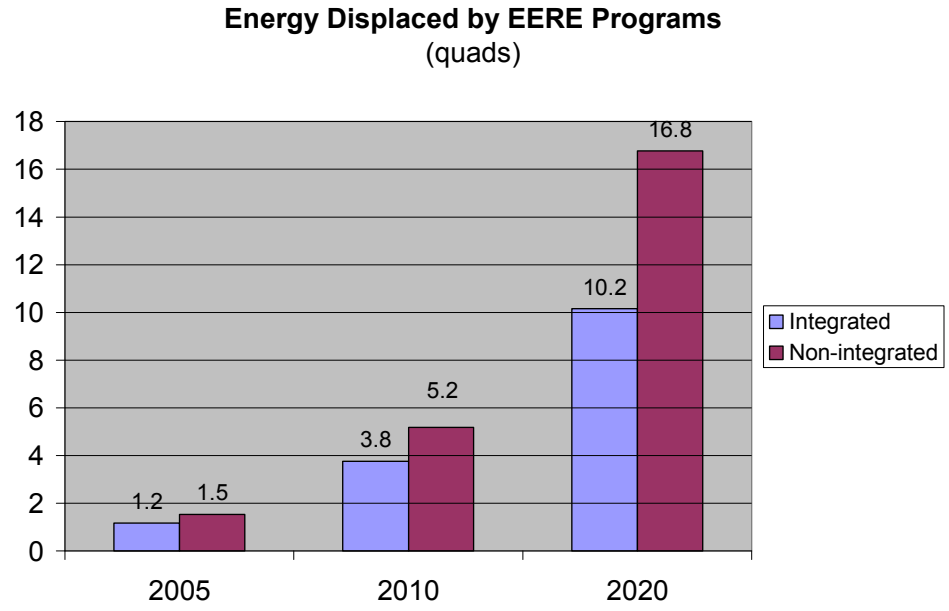
All planning units provided impact data, reports of which are contained in Appendix B. Sector and EERE level impact data are derived from the planning unit data and presented as ranges. Upper ranges are usually the non-integrated aggregations of planning unit analyses while lower ranges are derived from the integrated analysis described earlier. Program benefits are typically lower in the integrated analysis than the non-integrated analyses because inter- and intra-sector double-counting is eliminated, energy efficiency gains reduce the demand for electricity generation, and different models are used. Integrated and non-integrated totals placed in the FY 2001 Budget (Interior) are provided in Table 3. Figures 8-13 depict the integrated and non-integrated estimates for 2005, 2010 and 2020. Table 3 provides a planning unit breakdown of the non-integrated numbers. Figure 14 shows the impact the programs will have relative to projections under a "No EE" case – where the effects of EERE's programs are removed from AEO99 projections.

Three items need to be kept in mind when reviewing the impact estimates. First, estimates assume all program goals are met. Second, estimates represent annual benefits, not cumulative ones. Third, estimates are designed to capture the benefits of current and future EERE programs, not past ones. Program activities before FY 2001 resulting in energy, emission, or financial benefits in or after FY 2001 are excluded.[7] As a result, benefit estimates within the FY 2001 data call increase with time as technologies creating the benefits are diffused throughout the market. This is apparent in Figures 10-16. In future data calls estimates for the same year (e.g., 2010) will likely decrease because of the shorter time frame in which a technology has to diffuse.

[7] The indirect benefits of earlier programs may be included however. For instance, R&D programs that build upon past R&D or deployment programs that learn from past deployment efforts.

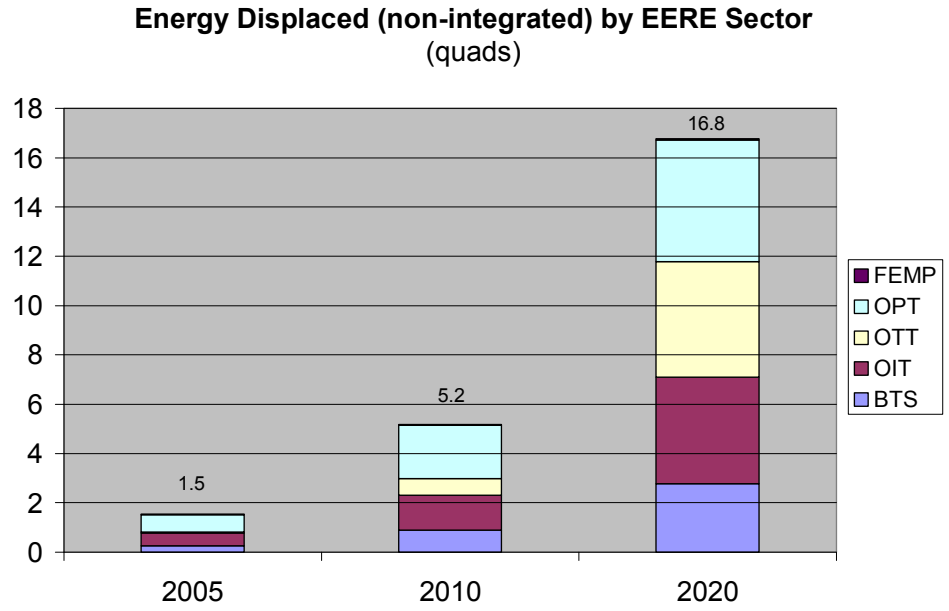
Energy Displaced. It is estimated that EERE programs will result in the displacement of 1.2-1.5 quads of primary energy in 2005, 3.8-5.2 quads in 2010, and 10.2-16.8 quads in 2020 (Figure 8).

Figure 8



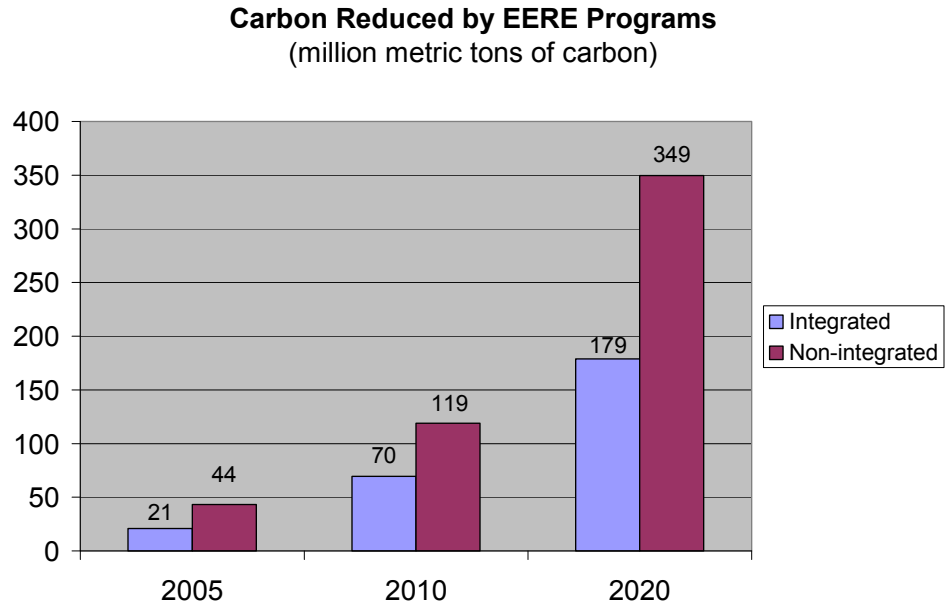
The distribution of energy savings across EERE's five sector offices is shown in Figure 9 below for the non-integrated estimates.

Figure 9



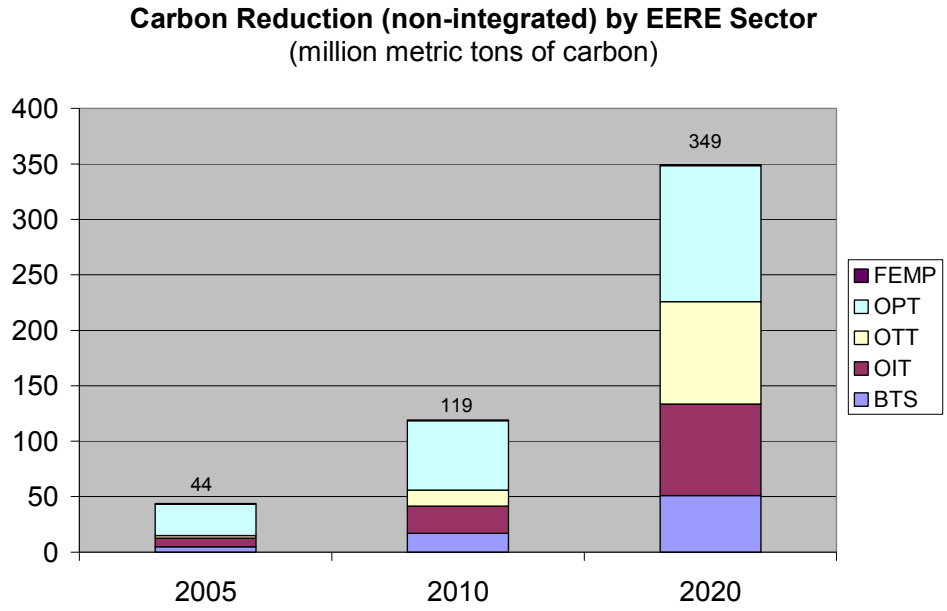
Carbon Reduction. The displacement of energy is estimated to result in the reduction of 21-44 million metric tons of carbon (MMTC) in 2005, 70-119 MMTC in 2010, and 180-349 MMTC in 2020 (Figure 10).

Figure 10



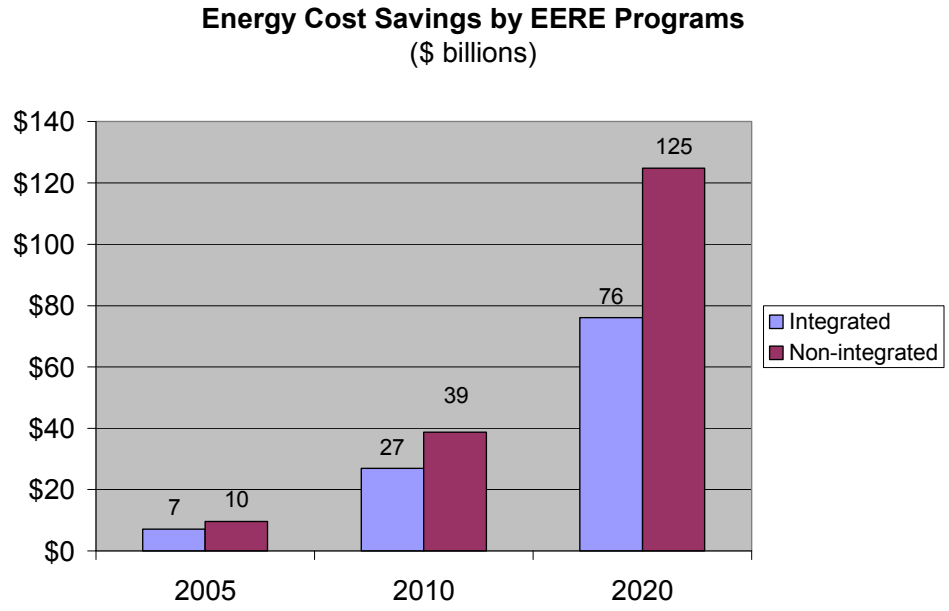
The distribution of carbon reduction across EERE's five sector offices is shown in Figure 11 below for the non-integrated estimates.

Figure 11



Energy Cost Savings. The displacement of energy will also result in energy savings of $7-10 billion in 2005, $27-39 billion in 2010, and $76-125 billion in 2020 (Figure 12).

Figure 12



The distribution of energy cost savings across EERE's five sector offices is shown in Figure 13 below for the non-integrated estimates.

Figure 13

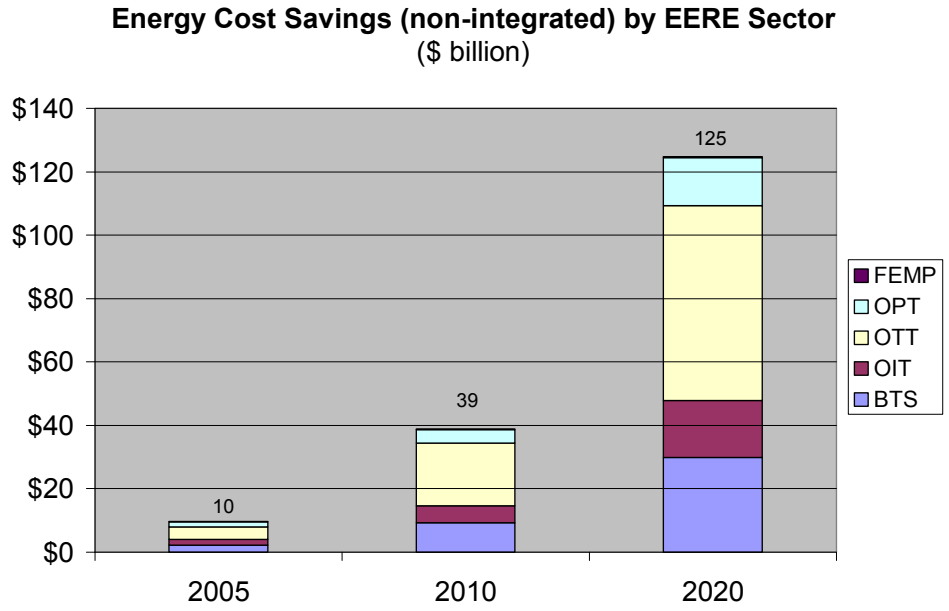


Figure 14 shows the impacts of EERE programs relative to the "No-EE" case, where the effects of EERE's programs are removed from AEO2001 projections. By 2020, EERE's programs could reduce total fossil energy consumption by 9-15% and reduce total carbon emissions by 9-17% compared to the "No-EE" case. Projected growth in fossil energy consumption could be reduced by 40-67% by 2020. Projected growth in carbon emissions could be reduced by 34-67% by 2020.

Figure 14

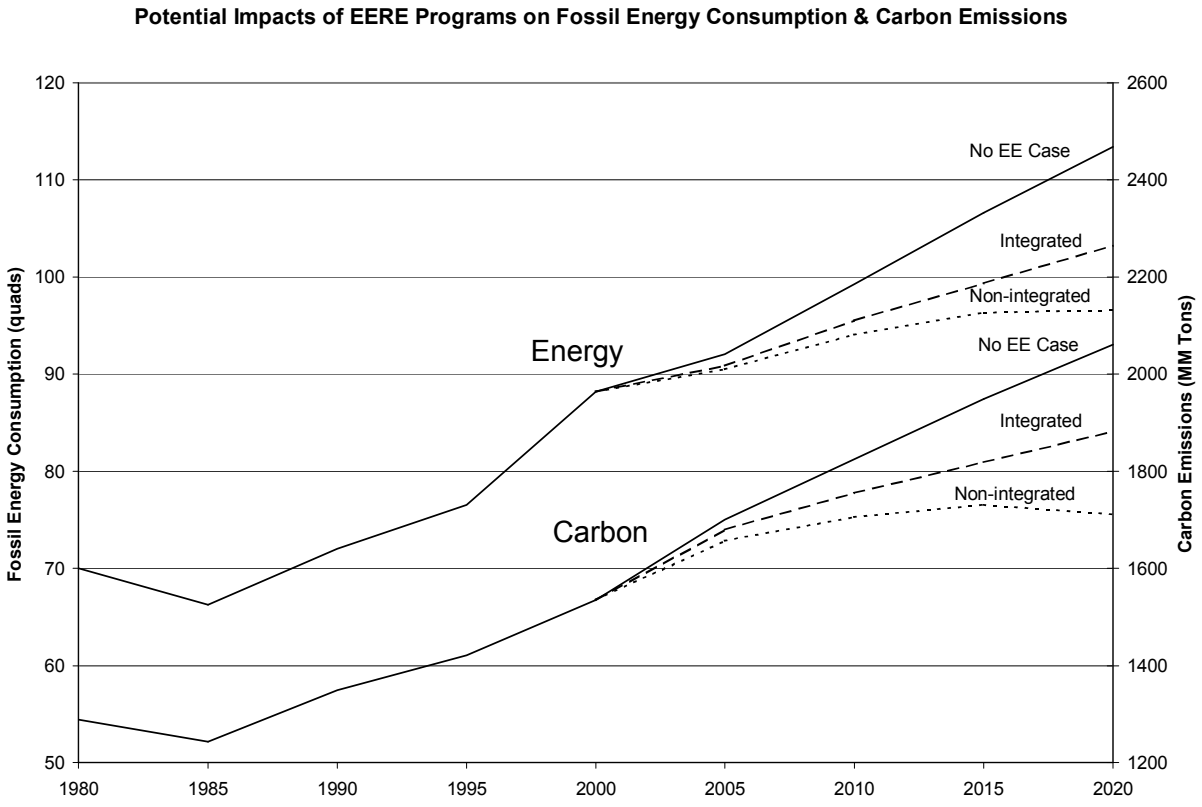


Table 2

Office of Energy Efficiency and Renewable Energy
EERE Programs Projected Benefits by Sector through the Year 2020

	Total Primary Energy Displaced (Quadrillion BTUs)			Energy Cost Savings ($ billions)			Carbon Reductions (million metric tons)		
	2005	2010	2020	2005	2010	2020	2005	2010	2020
Transportation *(oil savings, mbpd)*	0.03-0.04 *(0.06-0.14)*	0.5-0.7 *(0.3-0.5)*	2.8-4.7 *(1.5-2.5)*	0.8-3.9	9.4-19.8	31.5-61.5	0.7-2.3	8.9-14.4	54.5-92.1
Industry	0.5	1.3-1.4	3.4-4.3	1.8-1.9	5.4-5.5	16.6-18.0	7.9-8.4	23.0-24.5	54.6-82.7
Buildings	0.3	0.9	1.9-2.8	2.2	7.1-9.3	17.1-29.9	4.7-5.1	16.5-17.0	32.7-51.0
Federal	0.02	0.04	0.06	0.1	0.2	0.3	0.3	0.7	1.1
Power	0.3-0.7	1.0-2.2	2.0-4.9	1.6-2.1	4.2-4.8	10.6-15.2	6.5-28.5	20.4-62.5	36.0-122.6

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EE, based on assumptions for future energy markets derived from EIA's Annual Energy Outlook. EE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little. An integrated analysis model run by an external contractor controls for interaction effects across sectors.

At the sector level, we report a range of estimates with or without these interactions. For example, reductions in required new electricity generation due to energy efficiency improvements would reduce the potential market for a range of electricity supply options. When integrated and non-integrated estimates are virtually the same, no estimate range is shown. Totals for Transportation include impacts from the Biofuels program funded under the Energy and Water Development Appropriation. The Federal Energy Management Program is not included in the integrated analysis and therefore does not have a range of estimates.

Appendix A

EERE

GPRA Data Call

Fiscal Year 2003

Appendix B

Sector Metric Reports

Appendix C

Arthur D. Little Report on Review of Planning Unit Estimates

Appendix D

Integrated Modeling Report for GPRA 2003