EXECUTIVE SUMMARY

The Office of Energy Efficiency and Renewable Energy (EERE) of the U.S. Department of Energy (DOE) leads the Federal Government's efforts to provide clean, reliable, and affordable energy for America, through its nine research, development, demonstration, and deployment (RD^3) programs. EERE invests in high-risk, high-value research and development (R&D) that—conducted in partnership with the private sector and other government agencies—accelerates the development and facilitates the deployment of advanced clean energy technologies and practices. EERE designs its RD^3 activities to improve the Nation's readiness for addressing current and future energy needs.

Key Findings

Under a business-as-usual energy future, realization of these goals and the associated projected market outcomes would:

- Reduce the expected increase in U.S. demand for nonrenewable energy by 28% in 2025 and 78% in 2050.
- Reduce nonrenewable energy consumption starting in 2030. (**Figure ES.1**)
- Reduce the expected increase in U.S. consumer energy expenditures by 51% in 2025. (**Figure ES.2**)
- Save more than $200 billion per year in U.S. energy system net costs in 2050. (**Table ES.2**)
- Reduce the expected increase in annual U.S. carbon emissions by 31% in 2025 and 68% in 2050. (**Figure ES.3**)
- Reduce the expected increase in U.S. oil consumption (most of which is expected to originate from outside the United States) by 28% in 2025 and 120% in 2050.
- Result in declining oil consumption after 2025. (**Figure ES.4**)
- Reduce the expected increase in U.S. natural gas consumption, much of which is expected to originate outside the United States, by 10% in 2025 and 20% in 2050. (**Figure ES.5**)
- Avoid 118 gigawatts of additions to central conventional power in 2025. (**Table ES.2**)

Why Measure Benefits?

EERE develops benefits projections annually to maintain compliance with the Government Performance and Results Act (GPRA) of 1993 and the President's Management Agenda (PMA). GPRA requires Federal Government agencies to develop and report on output and outcome measures for each program. This analysis helps meet GPRA requirements by identifying the potential outcomes and benefits of realizing EERE program goals (outputs). The benefits

estimates do not reflect the technical risks or probabilities of realizing these goals, which are being addressed separately.[1]

The reported benefits reflect only the net annual improvement from 2005 to 2050 of program activities included in EERE's FY 2007 Budget Request (including subsequent-year funding) and do not include the benefits from past work. The benefits estimates assume continued funding for program activities consistent with multiyear program plans.[2] By basing estimated benefits on budget levels, the analysis addresses the performance-budget integration goal of the PMA.

Modeling the Market Outcomes of EERE's Technology Portfolio

EERE uses two energy-economy models—NEMS-GPRA07 and MARKAL-GPRA07—to estimate the impacts of EERE programs on energy markets. The NEMS-GPRA07 model is a modified version of the National Energy Modeling System (NEMS), the midterm energy model used by the Department of Energy's Energy Information Administration (EIA). The MARKAL-GPRA07 model is a modified version of the MARKet ALlocation (MARKAL) model, developed by Brookhaven National Laboratory and used by numerous countries worldwide. EERE uses NEMS-GPRA07 to estimate the midterm benefits of its programs, and MARKAL-GPRA07 to estimate the long-term benefits of its programs.

Choosing Metrics for EERE's Technology Portfolio

EERE has adopted a benefits framework developed by the National Research Council (NRC)[3] to represent the various types of benefits resulting from the energy efficiency technology improvements and renewable energy technology development supported by EERE programs. Specifically, EERE's benefits analysis focuses on three main categories of energy-linked benefits—economic, environmental, and security. The specific measures or metrics of these benefits estimated for FY 2007 are identified in **Table ES.1**. These metrics are not a complete representation of the benefits or market roles of efficiency and renewable technologies, but provide an indication of the range of benefits provided. EERE is continuing to take steps to more fully represent the NRC framework.

Assessing the Integrated Portfolio versus the Individual Programs

Analysts assess the impacts of EERE's technology development programs in two ways: 1) as an integrated portfolio, and 2) as a set of individual program goal cases. The integrated portfolio assessment involves running NEMS-GPRA07 and MARKAL-GPRA07 with all programs simultaneously represented. This provides a picture of the overall EERE portfolio that takes into account synergy and competition among the different technologies offered by each program. The individual program goal cases measure the isolated impact of technology development and

[1] A standard approach to teatment of risk is being developed for EERE's multiyear program plans.
[2] Funding levels may increase, decrease, or remain constant, depending on the program. See Appendices B through M for information on individual multiyear program plans.
[3] *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000*, National Research Council (2001). The NRC is the principal operating agency of the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE), providing services to the government, the public, and the scientific and engineering communities.

deployment success for each program. For these cases, each program is represented by itself in NEMS-GPRA07 and MARKAL-GRPA07 (in the absence of the other EERE programs).

Table ES.1. EERE FY 2007 Benefits Metrics

Primary Outcome	
Energy displaced	• Reductions in nonrenewable energy consumption (quadrillion Btu/yr)
Resulting Benefits	
Economic	• Reductions in consumer energy expenditures (NEMS-GPRA07 - billion 2002 dollars/yr) • Reductions in energy-system costs (MARKAL-GPRA07 - in billion 2002 dollars/yr)
Environmental	• Reductions in carbon dioxide emissions (mmtc equivalent/yr)
Security	• Reductions in oil consumption (mbpd) • Reductions in natural gas consumption (quadrillion Btu/yr) • Avoided additions to central conventional power (cumulative gigawatts)

The Annual Impacts of EERE's Technology Portfolio

Table ES.2 shows the estimated energy displaced and resulting benefits to the Nation of realizing the EERE program goals associated with the FY 2007 budget request. These impacts are the benefits expected in the reported year—that is, the benefits are annual, not cumulative (with the exception of avoided additions to conventional central power).

Table ES.2. Summary of Annual EERE Integrated Portfolio Benefits for FY 2007 Budget Request

EERE Midterm Benefits (NEMS-GPRA07)	2010	2015	2020	2025
Energy Displaced				
• Primary nonrenewable energy savings (quadrillion Btu/yr)	0.35	1.4	4.4	7.8
Economic				
• Energy-expenditure savings (billion 2003 dollars/yr)*	2.1	18	70	107
Environment				
• Carbon dioxide emission reductions (mmtce/yr)	8	26	86	166
Security				
• Oil savings (mbpd)	0.03	0.43	1.07	1.69
• Natural gas savings (quadrillion Btu/yr)	0.07	0.35	1.04	0.82
• Avoided additions to central conventional power (cumulative gigawatts)	0.53	11	54	118

EERE Long-Term Benefits (MARKAL-GPRA07)	2030	2040	2050
Energy Displaced			
• Primary nonrenewable energy savings (quadrillion Btu/yr)	14	25	32
Economic			
• Energy-system net cost savings (billion 2003 dollars/yr)*	63	138	207
Environment			
• Carbon dioxide emission reductions (mmtce/yr)	279	527	648
Security			
• Oil savings (mbpd)	3.9	8.0	11
• Natural gas savings (quadrillion Btu/yr)	2.0	2.0	2.8

* Midterm energy-expenditure savings only include reductions in consumer energy bills, while long-term energy-system cost savings also include the incremental cost of the advanced energy technology purchased by the consumer.

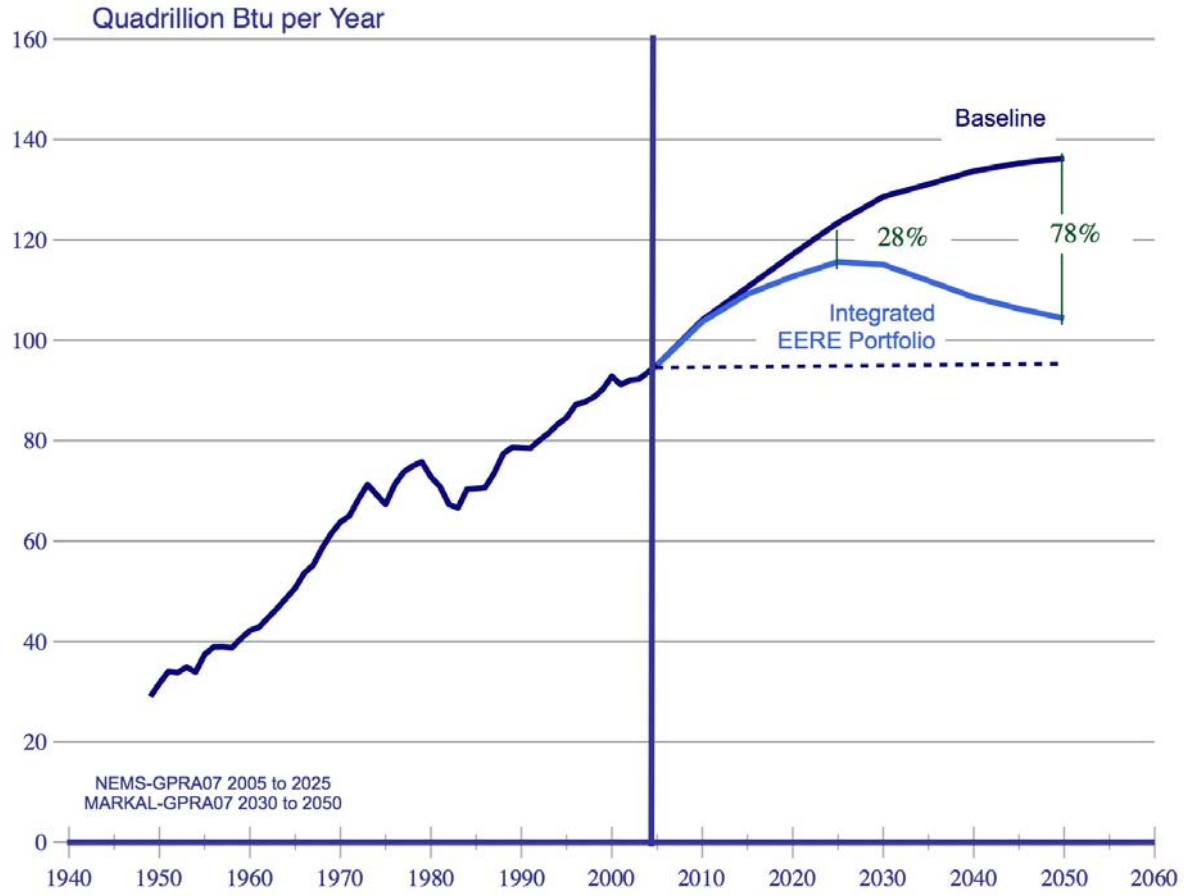

Figure ES.1. U.S. Nonrenewable Energy Consumption, 1949-2005, and Projections to 2050: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2025 and 2050 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2025 (or 2050) versus 2005 Data Source: 1949-2005, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 1.1, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

The portfolio of EERE technologies avoids 28% of the anticipated growth in annual U.S. nonrenewable energy demand in 2025.

By 2050, EERE's technology portfolio avoids almost 80% of the anticipated growth in annual U.S. nonrenewable energy demand.

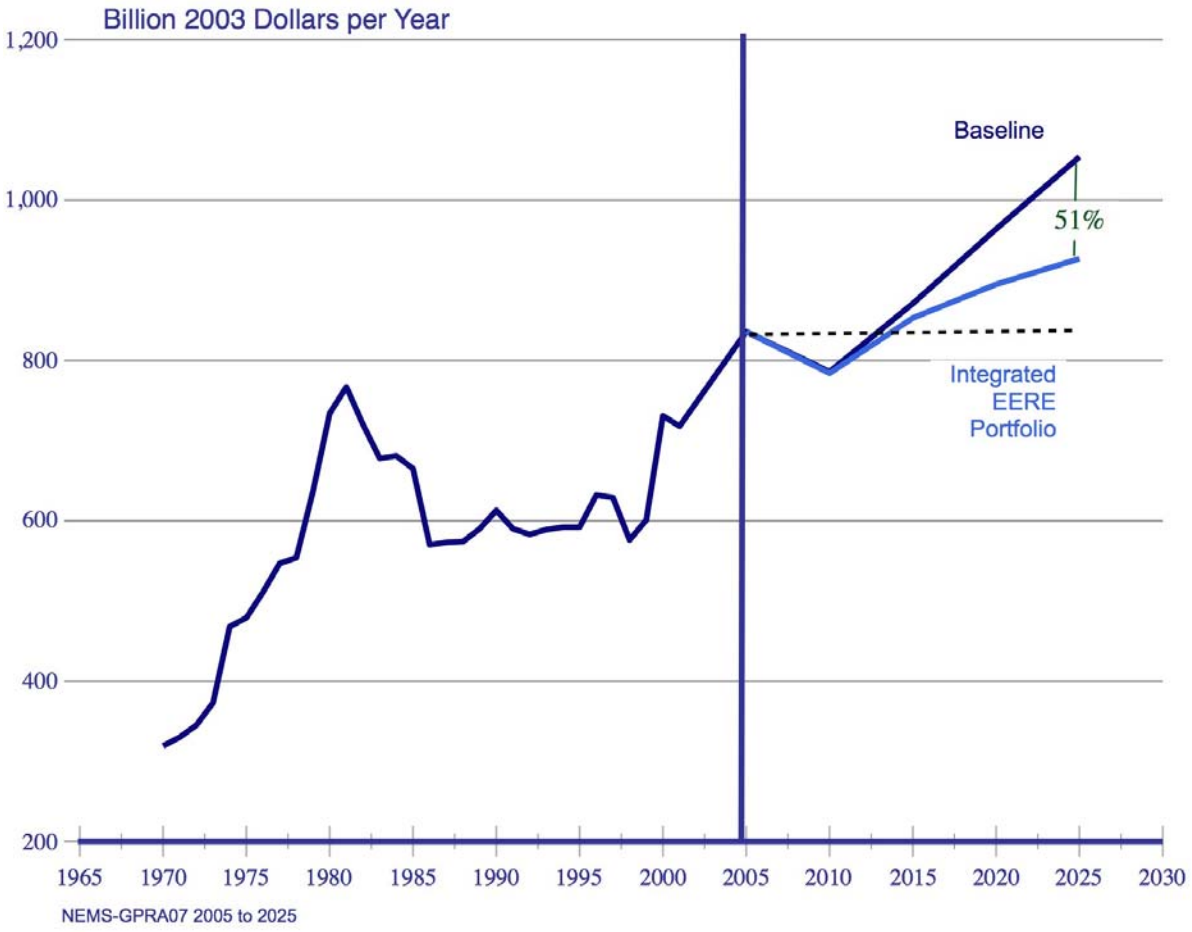

Figure ES.2. U.S. Total Energy Expenditures, 1965-2005, and Projections to 2025: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2025 and 2050 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2025 (or 2050) versus 2005. Data Source: 1970-2001, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 3.5 and Table D1, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

The portfolio of EERE technologies reduces the anticipated growth in annual U.S energy expenditures by 51% in 2025.

By 2050, EERE's technology portfolio provides annual U.S. energy-system net savings of more than $200 billion (see Table ES.2).

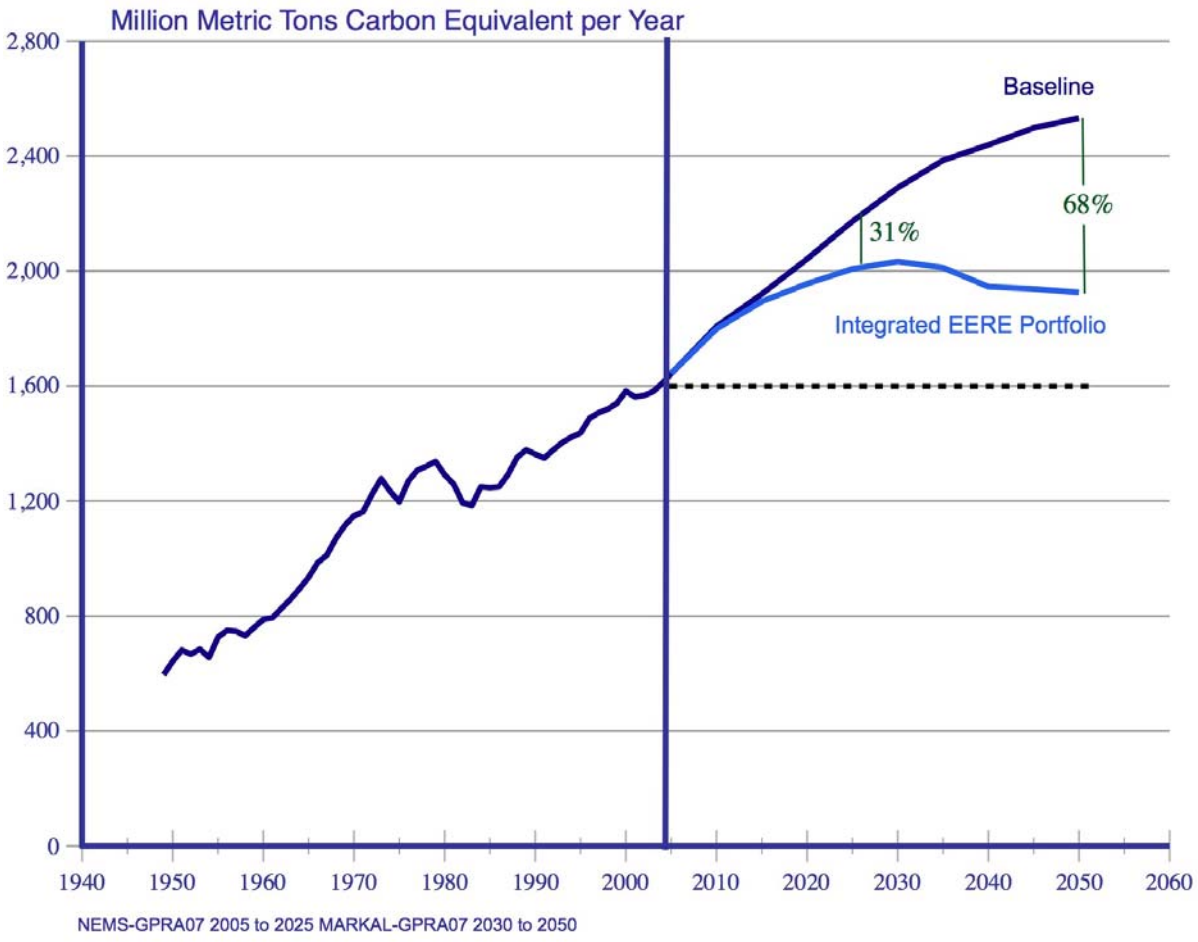

Figure ES.3. U.S. Energy-Related Carbon Emissions, 1949-2005, and Projections to 2050: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2025 and 2050 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2025 (or 2050) versus 2005. Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 12.2, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

The portfolio of EERE technologies avoids 31% of the anticipated growth in annual energy-related carbon emissions in 2025.

By 2050, EERE's technology portfolio avoids 68% of the anticipated growth in annual energy-related carbon emissions.

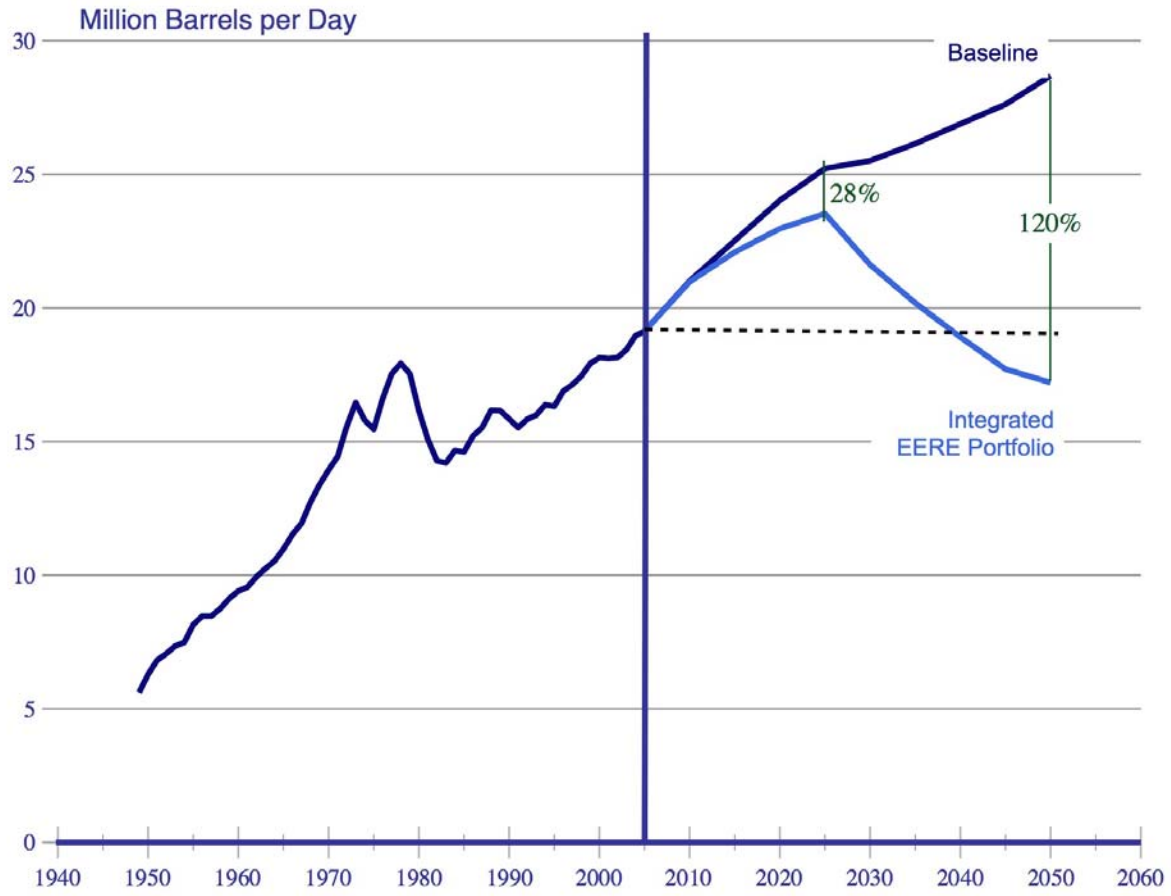

Figure ES.4. U.S. Oil Consumption, 1949-2005, and Projections to 2050: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2025 and 2050 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2025 (or 2050) versus 2005. Data Source: 1949-2000, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html. Data were converted from quads per year to mbpd using conversion factor of 5.8 million Btus per barrel of crude oil.

The portfolio of EERE technologies avoids 28% of the anticipated growth in annual U.S. oil demand in 2025.

By 2050, EERE's technology portfolio avoids 120% of the anticipated growth in annual U.S. oil demand in 2050.

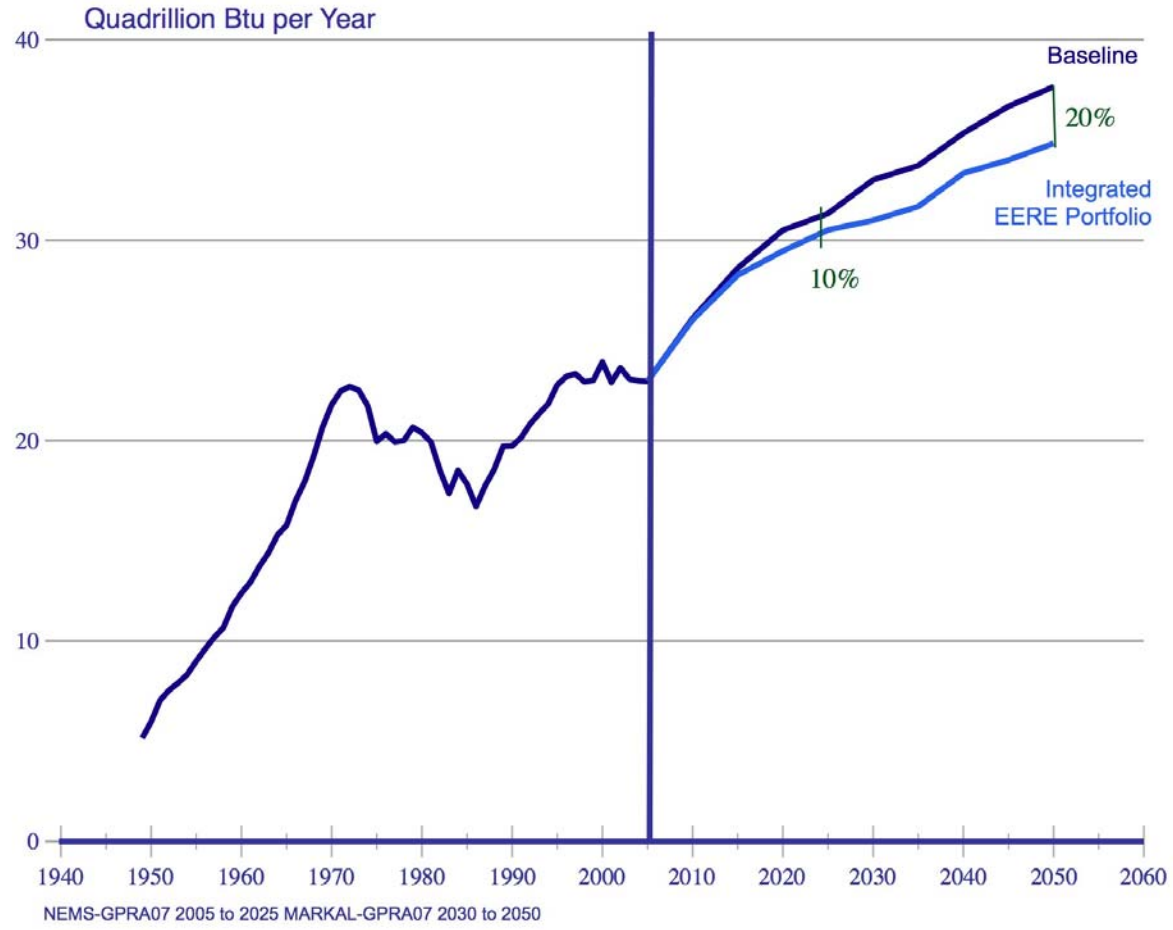

Figure ES.5. U.S. Natural Gas Consumption, 1949-2005, and Projections to 2050: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2025 and 2050 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2025 (or 2050) versus 2005. Data Sources: 1980-2000, EIA, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) August 2005, Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html; 2005-2025, NEMS-GPRA07; 2030-2050, MARKAL-GPRA07.

The portfolio of EERE technologies avoids 10% of the anticipated growth in annual U.S. natural gas demand in 2025.

In the long run, EERE's technology portfolio avoids 20% of the anticipated growth in annual U.S. natural gas demand in 2050

Individual Program Budgets and Benefits

Figure ES.6 and **Table ES.3** summarize individual program budgets and the results of the benefits analysis for individual program goal cases. Individual program benefits are shown for the midterm (2025) and for the long term (2050). The largest program budget is $225 million for the Weatherization and Intergovernmental Program (WIP), which includes $164 million for Low-Income Weatherization Assistance.

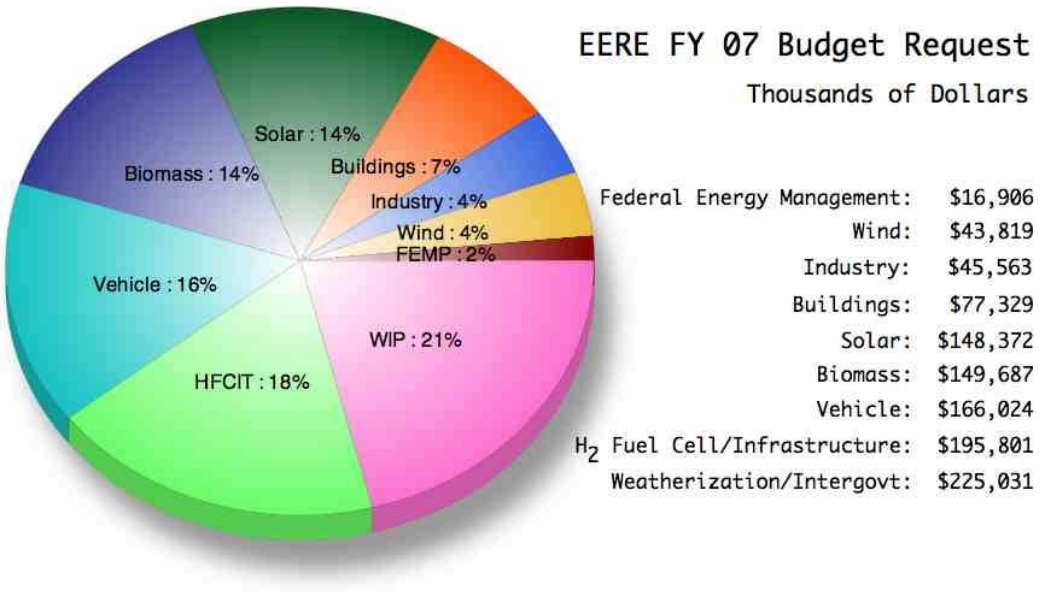

Figure ES.6. Proposed FY 2007 Budget Request for Technology Development

Data Sources: FY 2007 proposed budget information is available at http://www1.eere.energy.gov/ba/pba/budget_07.html

The picture that emerges from the individual program benefits presented here is one of robustness. Different technologies are positioned to dominate in the mid- and long term. Some technologies are best-suited to improving energy security by reducing our dependence on foreign oil. In addition, different programs emerge as important contributors to consumer energy savings versus those that emerge as important contributors to total energy system net cost savings.

While incomplete (because the estimates of the individual program goal cases are not based on integrated runs), the results indicate both the range and approximate level of benefits available to the Nation from funding the efficiency and renewable investments in EERE's portfolio of programs. They indicate a potential for making better use of existing technologies and for accelerating technological advances to make significant changes in our energy markets, which can drive the Nation to a period of level energy consumption.

Table ES.3. U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE): FY 2007 Funding Summary and Selected 2025 and 2050 Benefits by Program[4]

Program	FY 2007 Request (thousands $)	Nonrenewable Energy Displaced (quads/yr)		Energy Expenditure Savings (billions 2002$/yr)		Energy System Cost Savings (billions 2002$/yr)		Carbon Dioxide Emissions Reductions (million mtce/yr)		Oil-Use Reductions (mbpd)	
		2025	2050	2025	2050	2025	2050	2025	2050	2025	2050
Biomass	149,687	0.39	2.8	5.4	N/A	N/A	2.3	6.8	57.2	0.22	1.115
Building Technologies	77,329	1.99	5.4	17.3	N/A	N/A	130.0	44.7	124.2	0.04	0.475
Federal Energy Management	$16,906	0.02	0.1	0.2	N/A	N/A	0.0	0.4	0.7	0.00	0.002
Hydrogen, Fuel Cells, and Infrastructure Technologies	195,801	0.22	7.7	2.4	N/A	N/A	27.5	5.8	100.4	0.28	5.291
Industrial Technologies	45,563	ns	ns	ns	N/A	N/A	0.3	0.0	ns	0.00	ns
Solar Energy Technologies	148,372	1.07	5.2	7.9	N/A	N/A	9.2	28.8	110.8	0.00	0.025
Vehicle Technologies[5]	166,024	2.32	13.5	49.3	N/A	N/A	67.5	41.5	260.2	1.07	6.482
Weatherization and Intergovernmental	225,031	0.20	0.1	2.3	N/A	N/A	2.1	3.8	2.2	0.01	ns
Wind	43,819	3.10	3.9	17.6	N/A	N/A	2.1	69.1	100.8	0.09	0.006
Facilities and Infrastructure	5,935	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Program Direction and Management Support	104,954	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total EERE Integrated Portfolio Benefits**	**1,179,421**	**7.80**	**32**	**107**	**N/A**	**N/A**	**207**	**166**	**648**	**1.7**	**11**

** The total benefits of the EERE integrated portfolio differ from the sum of the individual program benefits, because interactions among programs are not accounted for in the individual programs

[4] Data Sources: FY 2007 proposed budget information is available at http://www1.eere.energy.gov/ba/pba/budget_07.html

[5] The Vehicle Technologies Program is run by the Office of FreedomCAR and Vehicle Technologies.

Scenario Analysis

In prior years, benefits estimates were reported for a single future energy scenario. Because of the uncertainties of energy and economic projections, this view of our energy future has limited value, especially in assessing the benefits of the full suite of technologies in the EERE portfolio. Assessing only one possible future may be particularly misleading for programs in which a significant part of the worth of the program may lie as a hedge against less likely, but possible, futures. Evaluating EERE's portfolio for a variety of possible futures offers insight about the robustness of the portfolio.

This year, we have taken the first step toward introducing scenario analysis for the EERE portfolio. Two scenarios were evaluated: 1) a high oil-price case, and 2) a carbon-constrained future. Because this is EERE's first foray into scenario analysis for GPRA benefits, we report the results as an appendix to this report (see **Appendix K**). Given the recent and sustained increases in crude oil and natural gas prices, the high fuels-price case is particularly relevant in understanding the value of EERE's portfolio, in what is likely to be the Base Case in future years. Similarly, understanding the impact of these programs under different carbon emissions scenarios is an increasingly important topic. We will evaluate our methodology for scenario analysis this year; and we expect that scenario analysis will be a part of the main benefits report for the FY 2008 budget request.

Future GPRA Benefits Development

As part of DOE's continuing efforts to implement the President's Management Agenda—and to be responsive to the advice offered by the National Academy of Sciences/National Research Council—DOE is in the process of integrating its GPRA benefits analyses across the offices of Energy, Science, and Environment (ESE). This integration process is expected to be fully completed for the FY 2010 budget request, but significant and important steps and progress will be evident along the way. The GPRA benefits analysis for the FY08 budget request will show a DOE-wide portfolio case, in which all offices' RD3 programs are combined. Further, EERE technologies' benefits will be evaluated relative to an ESE-wide baseline (as opposed to a baseline in which only EERE advanced technologies are removed from the AEO reference). Moreover, the inputs to the integrating models will be developed using common methodologies across all ESE offices. The result will be a much clearer picture of the benefits of the full DOE portfolio than has been represented to date.

Another major development afoot in DOE's benefits analysis is the treatment of risk and uncertainty. As in prior years, the benefits in this report are shown for Programs and the Portfolio assuming that RD3 goals are achieved and that they are achieved on time. It is also assumed that RD3 funding is continued as required. These assumptions represent a considerable simplification in a number of ways. First, for R&D there is considerable technical risk in what the actual output of the program activities might be. In fact, the output in a given year could be greater or less than the specified goal; or, alternatively, a specified goal may be achieved earlier or later than scheduled. Moreover, for a given output, the outcome is not known with certainty, because it will be affected by market risk considerations.