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 reliable, affordable, and environmentally sound energy for America, through its research, development, and deployment (RD&D) 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. The RD&D activities of EERE are designed to improve the nation's readiness to address future energy needs.

This document summarizes the results of the benefits analysis of EERE's programs, as described in the FY 2004 Budget Request. EERE is adopting a benefits framework developed by the National Research Council (NRC)[1] to represent the various types of benefits resulting from the energy efficiency technology improvements and renewable energy technology development prompted 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 indicators of these benefits estimated for FY 2004 are identified in **Table ES.1**. These measures 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 will be implementing additional portions of the NRC Framework as these elements are developed.

Table ES.1: EERE FY 2004 Benefits Metrics

Primary Outcome	
Energy displaced	• Reductions in nonrenewable energy consumption
Resulting Benefits	
Economic	• Reductions in consumer energy expenditures
Environmental	• Reductions in carbon dioxide emissions
Security	• Reductions in oil consumption • Reductions in natural gas consumption • Increases in renewable energy-generating capacity

Table ES.2 shows the estimated energy displaced and resulting benefits to the Nation of realizing the EERE program goals associated with the FY 2004 budget request. These impacts are the benefits expected in the reported year—that is, the benefits are annual, not cumulative. Between 2005 and 2020, under a business-as-usual energy future, realization of these goals would:

- Reduce the expected increase in U.S. energy demand by 41%. (**Figure ES.1**)
- Reduce the expected increase in U.S. consumer energy expenditures by 49%. (**Figure ES.2**)

[1] *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 science and engineering communities.

- Reduce the expected increase in annual U.S. carbon dioxide emissions by 39%. (**Figure ES.3**)
- Reduce the expected increase in U.S. oil consumption, most of which is expected to derive from outside the United States, by 31%. (**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 45%. (**Figure ES.5**)
- Increase the expected additions to U.S. renewable electric-generating capacity by 553% (**Figure ES.6**) and renewable electric generation by 517%. (**Figure ES.7**)

Table ES.2. Summary of EERE Integrated Portfolio Benefits for FY 2004 Budget Request

EERE Benefits (Annual)	2005	2010	2020
Energy Displaced (quads)	0.6	2.3	8.7
Economic Benefits			
• Energy-expenditure savings (billion 2000 dollars)	8.5	31.2	101.8
Environment			
• Carbon dioxide emission reductions (mmtce equivalent)	10.6	38.9	151.0
Security			
• Oil savings (quadrillion Btu)	0.2	0.7	3.3
• Natural gas savings (quadrillion Btu)	0.4	1.2	3.8
• Renewable electric-generating capacity (gigawatts)	1.5	7.2	39.4

These overall EERE benefits are measured from a Baseline Case, which accounts for the energy efficiency and renewable energy improvements that would be expected to occur even in the absence of EERE programs. The Baseline Case also includes improvements resulting from EERE program efforts in the past. As such, the reported benefits reflect only the net annual improvement from 2005 to 2020 of program activities included in EERE's FY 2004 Budget Request (including subsequent-year funding) and do not include the benefits from past work. Benefits estimates assume the funding will remain constant in inflation-adjusted dollars over the analysis period (or until the completion of the activity) and that the programs will achieve their technology goals and market targets by following multiple technology paths in parallel or sequentially until a successful avenue is found. Because funding continues over time, these technology and market improvements tend to be larger over time (e.g., more can be accomplished with a 10-year effort than a one-year effort).

EERE annually develops these benefits projections pursuant to the Government Performance and Results Act (GPRA) of 1993. The analysis summarized in this report is based on the technological and deployment progress expected by EERE programs, and generally assumes that programs continue to receive their requested funding levels through the completion of each activity. As such, the analysis addresses the performance-budget integration goal of the President's Management Agenda (PMA). This analysis also addresses the benefits criterion in the R&D Investment Criteria, developed by the Office of Management and Budget (OMB) as part of the PMA.

In order to help improve the consistency of estimates across EERE programs, EERE specifies a common methodology and set of assumptions to be used in developing benefits estimates.

The FY 2004 benefits estimates were developed following the guidance in place before the EERE reorganization occurred.[2] Baseline Case assumptions are updated annually to reflect new energy forecasts developed by the Energy Information Administration (EIA) (see **Appendix A**).

EERE uses a three-step process to estimate benefits across its portfolio:

(1) Establishment of the Baseline Case
(2) Determination of program and market inputs
(3) Assessment of program and portfolio benefits.

In Step 1, EERE uses an energy-economy model (NEMS-GPRA04), both to develop the Baseline Case and to estimate the impacts of EERE programs. This model is a modified version of the National Energy Modeling System (NEMS), the principal energy model used by the EIA. EERE modifies EIA's *Annual Energy Outlook 2002* Reference Case (AEO2002) forecast to remove any identifiable effects of EERE programs already included in the forecast. The Baseline Case, therefore, provides a consistent representation of business-as-usual future energy markets without the benefits of EERE programs, and ensures consistent assumptions about future energy prices, conversion factors, economic growth, and other external factors, which might affect the analysis results. A summary of the Baseline Case results is included in **Appendix A.**

In Step 2, once the Baseline Case is established, the EERE program's technology goals (or outputs) are assessed with regard to their likely market impacts. Although many of the program outputs can be characterized by improvements in the costs and performances of the technologies, some of the programs (particularly deployment assistance programs that include activities such as information dissemination, market assessments, and codes and standards) characterize their outputs as market-penetration levels. Because the success or failure of energy technologies can depend heavily on the external-to-DOE market and policy conditions found in each energy market, such conditions must often be taken into account on a case-by-case basis in estimating individual program benefits. **Appendices B through E** describe the market-specific analyses undertaken in this step.

In Step 3, the program- and market-specific information from Step 2 is incorporated into NEMS-GPRA04, which enables accounting for market feedbacks and interactions that can change the ultimate level of energy savings associated with realizing each program's goals. Where program activities cannot be directly modeled in NEMS-GPRA04, initial energy impacts are estimated "off-line" (e.g., without the use of a full, program-wide model). For the FY 2004 benefits analysis, EERE undertook a new approach of adjusting these off-line estimates to account for areas of overlapping program impacts. This (usually) downward revision was made based on judgment of the Integrated Modeling Team of analysts. The resulting benefits estimates of these individual program analyses are listed by program—along with FY 2004 program budgets, in **Table ES.3** below.

[2] Prior to the reorganization, estimates of benefits were made based on guidances developed by EERE's then Office of Planning, Budget, and Outreach. The FY 2004 analysis was begun using the pre-existing guidance for FY 2003 (see http://www.eere.energy.gov/office_eere/ba/gpra_estimates_fy03.html).

NEMS-GPRA04 is also run with all programs simultaneously represented in order to derive estimates of the benefits of the EERE portfolio overall. This portfolio analysis accounts for interactions among EERE's programs and tends to report slightly reduced benefits compared to the sum of the individual programs.[3] These fully integrated results are listed in **Table ES.2,** above, and displayed in the graphs in this **Executive Summary**. Specific details of the representation of the program outputs in NEMS-GPRA04 and the underlying program analysis and documentation are provided in **Chapter 3** of this report.

The budget-planning year for the FY 2004 budget request was a year of transition within EERE. A major reorganization resulted in the consolidation and realignment of 31 programs (analyzed as 46 "GPRA units") across five sectors to just 11 programs (analyzed as 12 "GPRA units" for better correspondence with the budget). The FY 2004 benefits analysis began under the old organization, but concluded with the new organization. As a result, the documentation for Step 2—individual program and market analysis—does not reflect the new program structure nor the more-integrated approach to benefits estimates made possible by the reorganization. Nonetheless, it provides the reader with a sense of the ways in which the inputs to the NEMS-GPRA04 Benefits Estimates described here were calculated.

EERE is pursuing a number of improvements to its benefits analysis. Important changes planned for analysis of the benefits of the FY 2005 budget request include:

- Extension of the benefits projection time frame to 2050 to better capture the longer-term benefits of programs such as the Solar Energy Technologies Program and the Hydrogen, Fuel Cells, and Infrastructure Technologies Program.
- Greater streamlining and consistency in the development of program-level benefits estimates.

In addition, EERE is developing methods for linking estimates of benefits from both past and future program efforts into the overarching NRC benefits framework noted above—as well as developing methods for estimating the option value of preparing the Nation for possible future energy needs beyond business-as-usual. Finally, EERE is developing a more systematic way of representing program and technology risk. Although not part of this benefits analysis *per se*, information on risk is recognized as an important component in the application of benefits information to portfolio management.

[3] In previous years, the difference between the sum of individual program results and the portfolio results were much larger; the small difference in this year's analysis is due in large part to the adjustments made to the off-line estimates in Step 2, described above, as well as the use of NEMS-GPRA04 for program-level results.

Table ES.3. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy: FY 2004 Funding Summary and Selected 2020 Benefits by Program[4]

	FY 2004 Request ($ thousands)	Energy Displaced (quads)	Energy Expenditure Savings (billions 2000$)	Carbon Dioxide Emissions Reductions (million MTce)	Oil-Use Reductions (quads)
Hydrogen, Fuel Cells, and Infrastructure Technologies	165,482	0.2	3.9	4.6	0.2
FreedomCAR and Vehicle Technologies	157,623	1.6	25.5	29.8	1.5
Weatherization and Intergovernmental	369,460	1.4	14.7	26.3	0.6
Solar Energy Technologies	79,693	0.1	1.4	2.4	0.0
Wind and Hydropower	49,089	1.2	5.4	20.9	0.1
Geothermal Technologies	25,500	0.4	1.8	7.5	0.0
Distributed Energy and Electric Reliability	128,650	0.5	9.0	8.5	0.0
Building Technologies	56,563	1.3	16.3	22.7	0.1
Industrial Technologies	64,429	2.1	20.2	36.3	0.5
Biomass	78,558	0.4	1.9	3.6	0.3
Federal Energy Management	22,262	0.1	0.8	1.3	0.0
National Climate Change Technology Initiative	24,500	N/A	N/A	N/A	N/A
Facilities and Infrastructure	4,950	N/A	N/A	N/A	N/A
Program Direction	93,241	N/A	N/A	N/A	N/A
Sum of programs *	**1,320,000**	**9.3**	**100.9**	**163.9**	**3.4**

* The sum of program benefits differs from the EERE portfolio values in Table ES.2, because interactions among programs are not accounted for in the individual estimates. Sums may not total due to rounding.

[4] Budget request from *FY 2004 Budget-in-Brief*, U.S. Department of Energy, Energy Efficiency and Renewable Energy, http://www.eere.energy.gov/office_eere/pdfs/fy04_budget_in_brief.pdf.

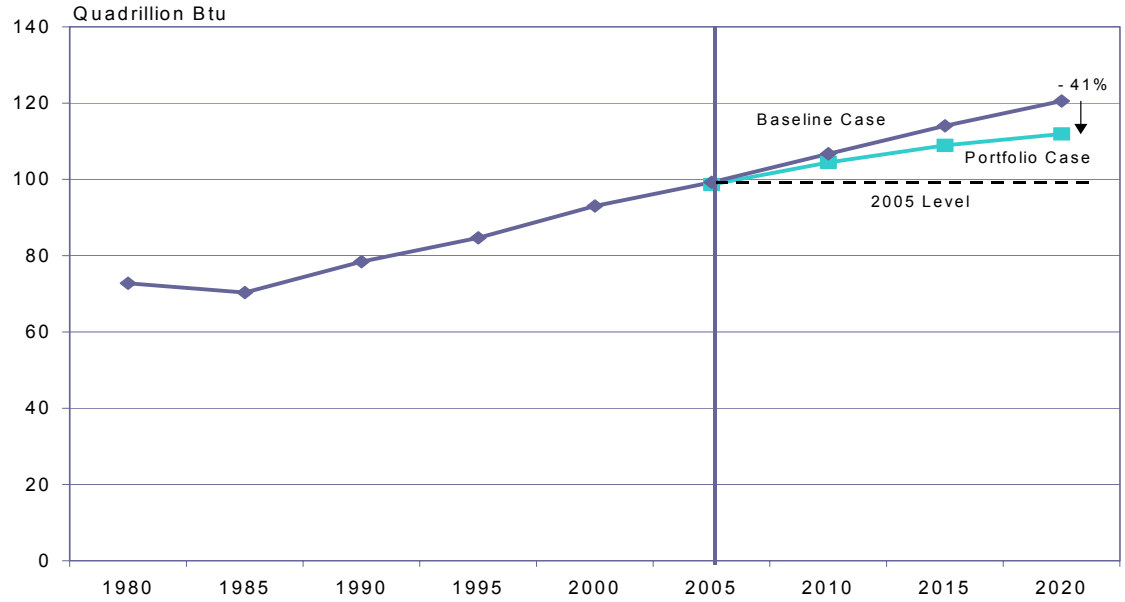

Figure ES.1. U.S. Nonrenewable Energy Consumption, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for year 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

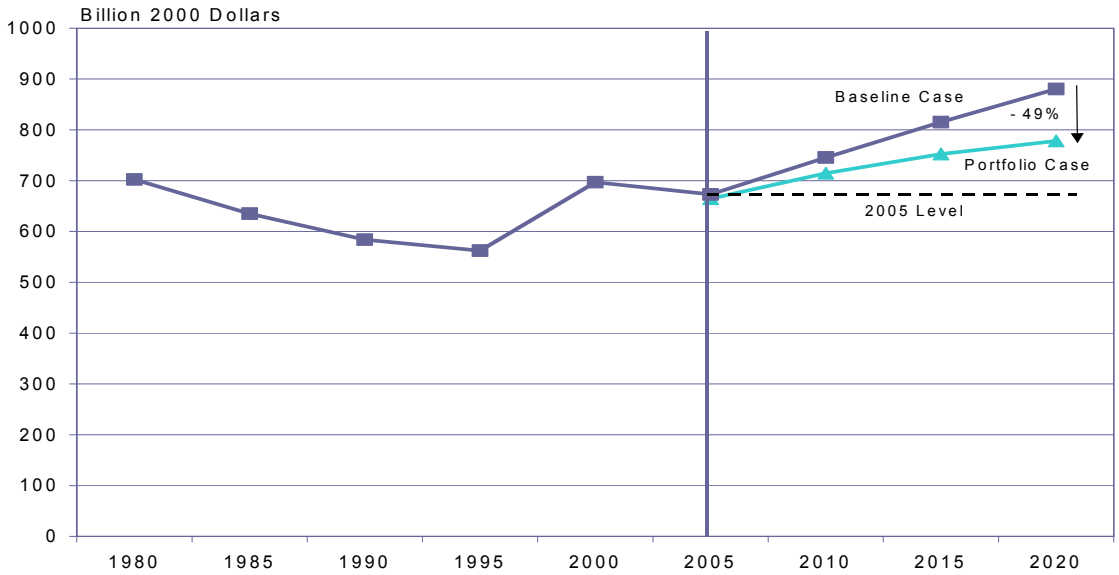

Figure ES.2. U.S. Total Energy Expenditures, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Sources: 1980-1995: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 3.4 and Table E1, Web site http://www.eia.doe.gov/emeu/aer/contents.html; 2000: Energy Information Administration, *Annual Energy Outlook 2002*, DOE/EIA-0383 (2002), Supplemental Table 20.

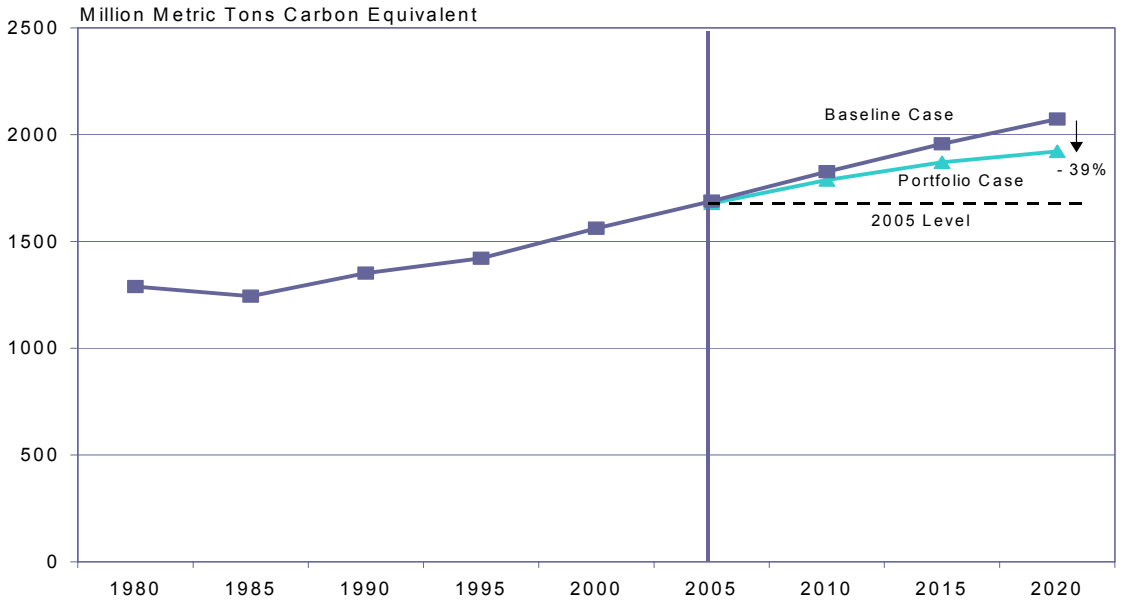

Figure ES.3. U.S. Carbon Dioxide Emissions, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 12.2, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

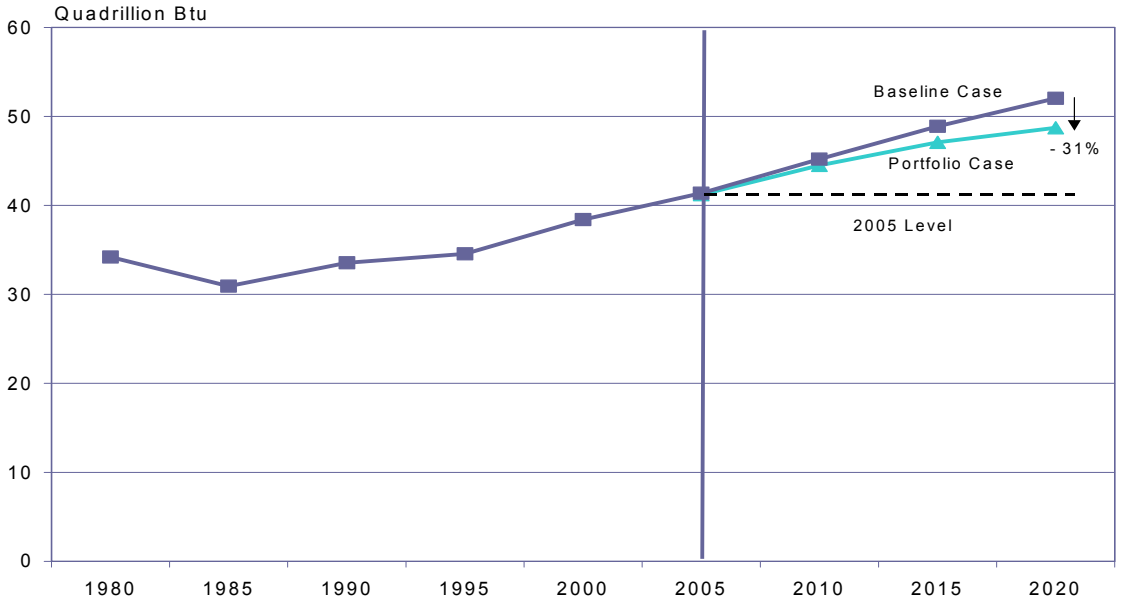

Figure ES.4. U.S. Oil Consumption, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

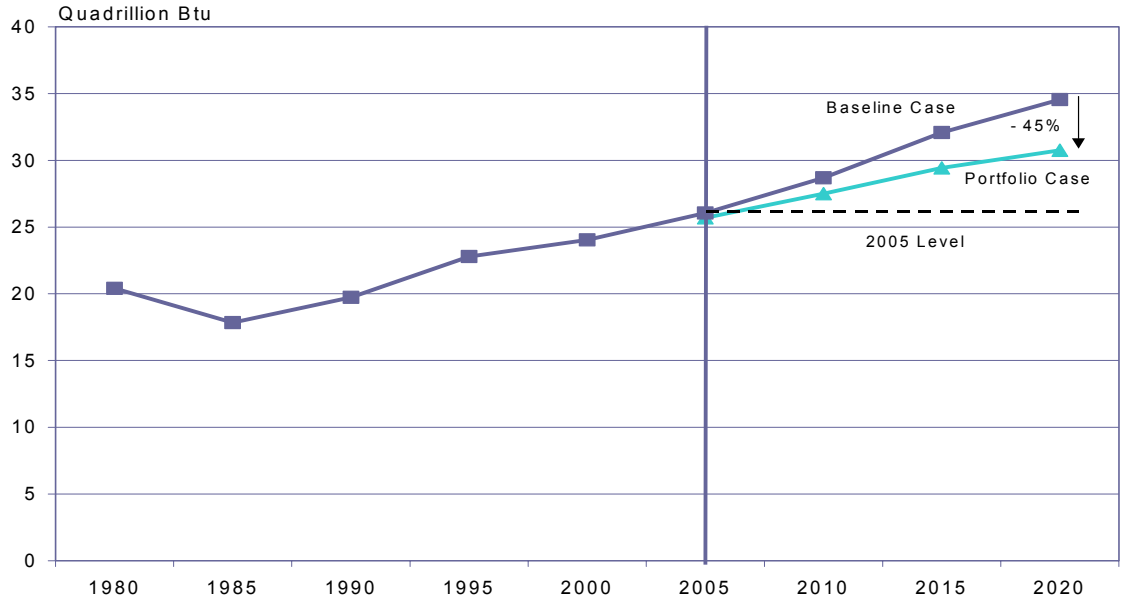

Figure ES.5. U.S. Natural Gas Consumption, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

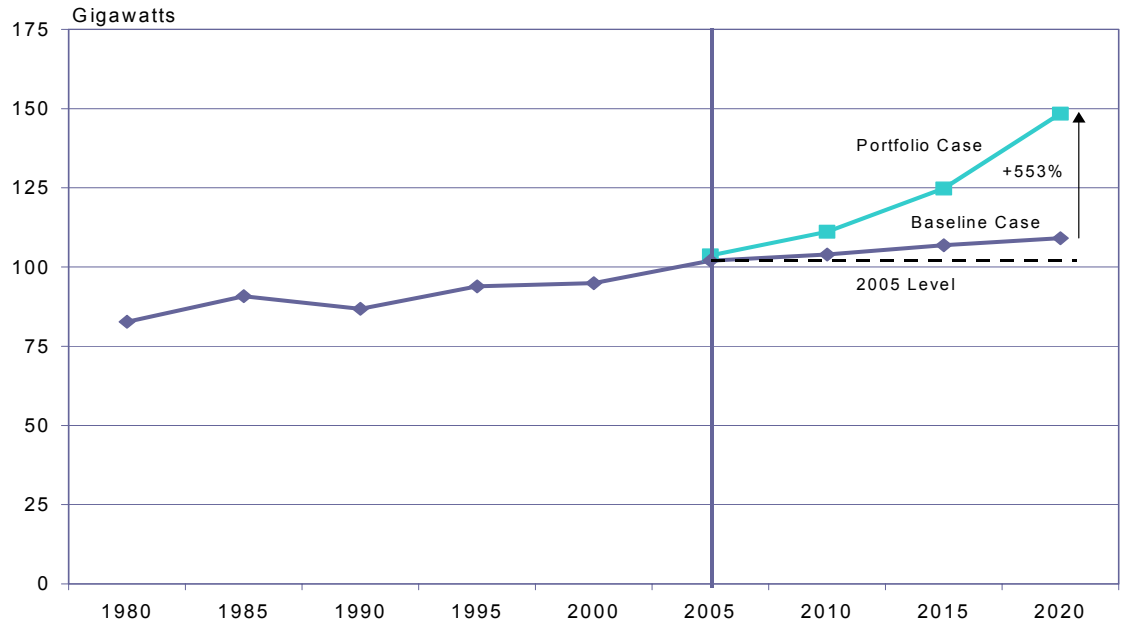

Figure ES.6. U.S. Renewable Electricity Capacity, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 8.7a, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

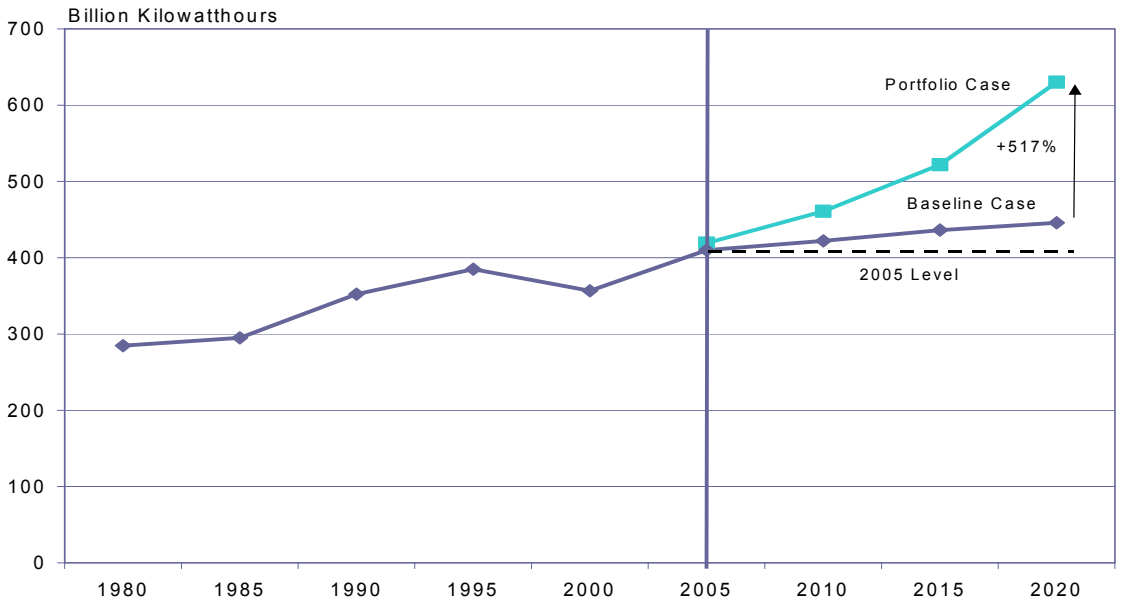

Figure ES.7. U.S. Renewable Electricity Generation, 1980-2000, and Projections to 2020: Baseline and Portfolio Cases

Note: The percentage change in the chart shown for 2020 is the difference between the Baseline Case and the Portfolio Case, compared to the difference between the values of the Baseline Case in 2020 versus 2005.
Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001), Table 8.2a, Web site http://www.eia.doe.gov/emeu/aer/contents.html.