CHAPTER 3

FY 2004 BENEFITS ESTIMATES

The Office of Energy Efficiency and Renewable Energy (EERE) estimates expected benefits for its overall portfolio and for each of its 11 programs. Benefits for the FY 2004 budget request are estimated for 2005-2020. The year 2020 is the last date for which an independent reference forecast was available at the time of this analysis.

Benefits estimates are intended to reflect the value of program activities from 2005 forward. These estimates do not include the impacts of past program success, nor technology development or deployment efforts outside EERE's programs. This distinction is difficult to implement in practice, as many research and deployment activities provide continuous improvements that build on past success; and because EERE programs are leveraged with private-sector and other government efforts.

Outcomes and Benefits Metrics

The energy efficiency improvements and additional renewable energy production facilitated by EERE's programs reduce the consumption of traditional energy resources. Reducing energy consumption affords the Nation a number of economic, environmental, and energy security benefits.[1] The extent of these benefits depends on factors including which energy sources are reduced, the costs of the new technologies, and the emissions performance of the energy technologies used. Different EERE portfolios would produce a different mix of benefits, even if the overall level of primary energy savings were the same.

The public benefits resulting from these reductions in the use of traditional energy resources take many forms. Environmental improvements, for instance, can include reductions in local, regional, or global air emissions; reduced water pollution; noise abatement, etc. These public benefits are typically difficult to measure directly, and some aspects are not quantifiable. EERE has developed a set of *indicators* intended to provide a sense of the magnitude and range of the benefits its programs provide the Nation. EERE estimates benefits for the following categories:

Primary Outcome:

> **Energy Displaced:** Displaced energy (or energy savings) is calculated as the difference in nonrenewable energy consumption with and without the technologies and market improvements developed by EERE programs. Energy savings are measured on a primary basis, accounting for the energy consumed in producing, transforming, and transporting energy to the final consumer. Energy savings from underlying, private-sector improvements in technologies are not counted.

[1] This is a categorization of EERE's benefits estimates based on the framework developed by a National Research Council (NRC) committee. The framework is described in more detail in the Introduction.

Primary Benefits:

Economic Benefits: Economic benefits are the potential for EERE technologies to make energy more affordable, increase economic productivity and GDP, reduce the impact of energy price volatility on the U.S. economy, and improve the balance of trade.

EERE currently utilizes one primary measure related to affordability:

Energy-expenditure savings: Energy-expenditure savings are calculated as the difference in total consumer energy bills, with and without the availability of technologies and market improvements developed by EERE technologies. This is a gross savings estimate, as it does not include the incremental cost to end users of acquiring the new technology. The EIA NEMS model does not currently have the capability to provide net costs.

Energy efficiency improvements and increased use of nonfuel renewable energy reduce energy bills in two ways. Consumers who make energy efficiency or renewable energy investments benefit directly through reduced purchases of energy (quantity component). In addition, the lower demand for energy reduces the price of energy for all consumers (price component). Both elements are included in this metric.

Environmental Benefits: Environmental benefits include lower carbon, SOx, NOx, and other air emissions associated with renewable energy use and energy efficiency improvements, improvements in water quality, reductions in noise, a reduced "footprint" for energy exploration and development, and the health and ecological implications of each of these.

Of these, EERE currently estimates only the impacts of its programs on carbon emissions:

Carbon savings: Carbon savings (i.e., emission reductions) are calculated as the difference in the level of U.S. energy-related carbon emissions with and without the availability of EERE technologies and market improvements.

Carbon emission reductions result from the reductions in fossil fuel consumption when these new supply (renewables) and demand (energy-efficient) technologies are used in the market. As with the energy-savings metric, emission reductions count the effect of upstream energy savings in producing, transforming, and transporting energy to the end user.

Security Benefits: Security benefits include improvements in the reliability of fuel and electricity deliveries, reduced likelihood of supply disruptions, and reduced impacts from an energy disruption.

EERE contributes to these security gains by reducing U.S. reliance on imported fuels, increasing the diversity of domestic energy supplies, increasing the flexibility and diversity of the Nation's energy infrastructure, reducing peak demand pressure on that infrastructure, and providing backup energy sources in the event of outages. Of these aspects of energy security, EERE has developed indicators related to concerns about fuel imports and the reliability and diversity of electricity supplies:[2]

1. **Oil savings:** Oil savings are calculated as the difference in total U.S. oil consumption with and without EERE technologies and market improvements.
2. **Natural gas savings:** Natural gas savings are calculated as the difference in total U.S. natural gas consumption with and without EERE technologies and market improvements.
3. **Electricity generation capacity:** Electricity-generation capacity impacts are calculated variously as the difference in renewable power-generating capacity (capacity additions); the amount of electricity capacity displaced by efficiency improvements (displaced capacity); or the amount of distributed generation, with and without EERE technologies and market improvements.[3]

The natural gas and electricity capacity security metrics are new for EERE this year. A natural gas measure was added to reflect the growing importance in the U.S. energy mix of natural gas imports. The electricity-generation capacity metric reflects increasing concerns about the adequacy of traditional, centralized electricity systems to provide reliable electricity in the years and decades ahead.

In interpreting these results, it is important to remember that while the benefits of efficiency and renewable technologies are multifaceted, they are not always distinct or additive. Improvements in balance-of-trade or economic productivity, for instance, are contributory to improved GDP and not additional to improved GDP. Nonetheless, identifying the various types of economic or other contributions can help relate EERE's portfolio to various economic or other policy concerns.

Each of these metrics is ideally measured as a net benefit (e.g., energy bill savings, less the cost to the consumer of investing in the efficient or renewable technology; any negative, as well as positive, environmental impacts). EERE's current modeling tools lack the ability to back out some of these types of costs. Carbon emission reductions, as well as oil and natural gas savings are calculated on a net basis (e.g., accounting for cases in which EERE programs tend to increase rather than decrease use or emissions); while consumer-expenditure estimates do not reflect the costs to consumers of purchasing more efficient or cleaner technologies.[4]

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[2] The inclusion of reliability improvements within the security category was part of the NRC suggestions on how to structure the types of EERE benefits. The 2003 blackout in the Midwest and New England indicates the extent to which security and reliability are intertwined.

[3] These measures are not additive and are not the same as a measure of peak load reduction for conventional electricity or of improved reliability. Renewable capacity additions are not equivalent to capacity additions avoided because of differences in capacity factors and coincidence of renewable generation at system peak (i.e., peak electricity generation output of wind, for example, may not coincide with the peak demand of the utility system to which it supplies power).

[4] EERE is in the process of adopting an additional economic model, which is able to provide estimates of net economic costs. This model, MARKAL, will also estimate benefits out to 2050.

Portfolio Benefits

Table 3.1 presents the economic, environmental, and security benefits of EERE's overall portfolio of investments in improved energy-efficient technologies, renewable energy technologies, and assistance to consumers in adopting these technologies.

Table 3.1. Annual EERE Portfolio Benefits for FY 2004 Budget Request for Selected Years

EERE Portfolio Benefits	2005	2010	2020
Energy Displaced (quadrillion Btu)	0.6	2.3	8.7
Economic Benefits:			
▪ Energy-expenditure savings (billion 2000 dollars)	8.5	31.2	101.8
Environmental Benefits:			
▪ Carbon dioxide emissions reductions (million metric tons carbon 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

Energy Displaced: EERE's portfolio significantly dampens the expected growth in conventional energy consumption. Absent the results of EERE's programs,[5] energy use is expected to grow by nearly 21 quads from 2005 to 2020, to about 121 quadrillion Btus of energy. EERE's investment portfolio would reduce nonrenewable energy consumption by nearly 9 quadrillion Btu by 2020, or more than 40% of the expected incremental growth in energy demand over this time period (see **Figure 3.1**).

These estimates account for interactions among program results. While some program activities reinforce each other to produce larger benefits than would be evident from each program's individual efforts, programs compete for the same markets in other cases. For example, the various renewable technology programs compete in the electricity-generation market. In addition, activities being funded by some programs reduce the potential market for technologies being developed in other programs. As an example, reductions in electricity demand due to efficiency improvements reduce the size of the generation market and, therefore, the market opportunity for renewable-generation technologies. The overall effect of these interactions is to reduce EERE benefits in 2020 by about one-half quad compared to the sum of the individual program benefits (i.e., Program Case, see **Figure 3.2**).

Economic Benefits: The energy savings resulting from these efficiency and renewable energy contributions are estimated to reduce annual consumer energy expenditures in 2020, expressed in real 2000 dollars, by $102 billion relative to the baseline projection of $880 billion (**Figure 3.3**), or about 12 percent of the nation's expected energy bill.

[5] See Chapter 1 for information on how EERE's "no-program" Baseline Case is developed.

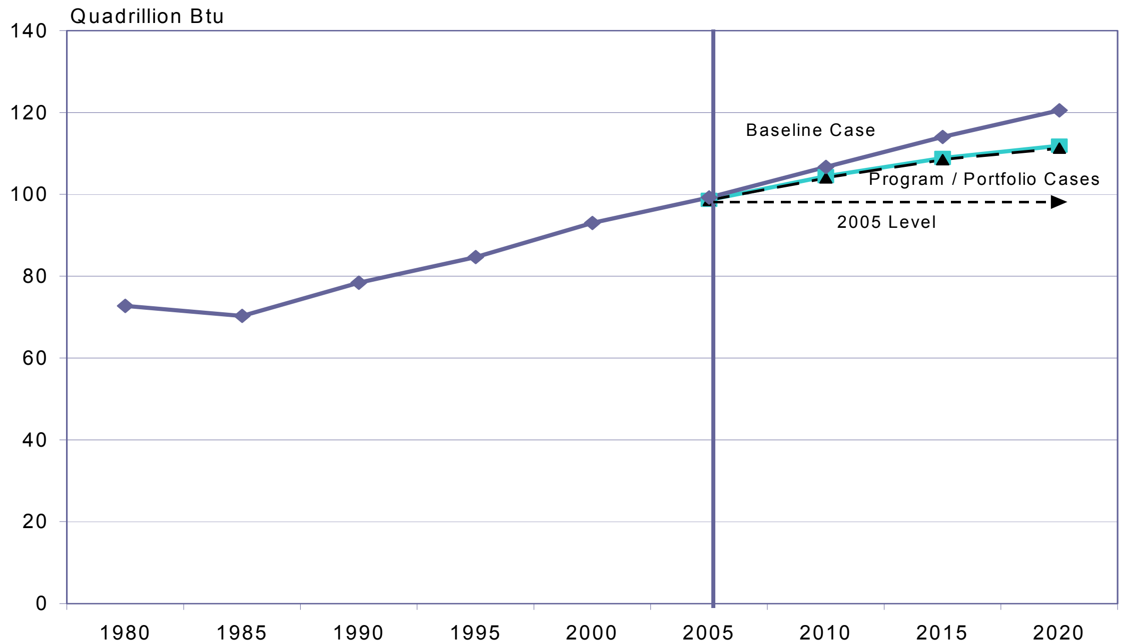

Figure 3.1. U.S. Nonrenewable Energy Consumption, 1980-2000, and Projections to 2020: Baseline, Program, and Portfolio Cases

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

Figure 3.2. Comparison of Program and Portfolio Nonrenewable Energy Consumption Estimates, 2005, 2010, and 2020 (quadrillion Btu)

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 1.3, Web site: http://www.eia.doe.gov/emeu/aer/contents.html.

While these energy bill savings appear to be large, they represent both reduced energy purchases and lower energy prices resulting from reductions in demand. They also exclude incremental costs to end users of acquiring the new technology because the EIA NEMS model does not currently have the capability to determine this. Lower energy demand dampens fuel costs and reduces the need for expensive new energy infrastructure expenditures. Lower energy prices improve affordability for all consumers, including those who make no additional efficiency or renewable investments as a result of EERE's activities.

Figure 3.3. U.S. Total Energy Expenditure, 1980-2000, and Projections to 2020: Baseline, Program, and Portfolio Cases

Data Source, 1980-1995: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 3.4 and Table E1, Web site http://www.eia.doe.gov/emeu/aer/contents.html.
Data Source, 2000: Energy Information Administration, *Annual Energy Outlook 2002*, DOE/EIA-0383 (2002) (Washington, D.C., December 2001), Supplemental Table 20.

EERE's Weatherization Grant Program specifically targets energy savings and energy bill reductions for low-income families. At the FY 2004 request level, the program directly funds weatherization of nearly 230,000 low-income-family homes per year, including homes weatherized by additional governmental and utility funding. In FY 2004, these homes save each year an average ranging from $3,429 in the Midwest to $1,814 in the West. By 2020, this will translate into about $917 million in annual energy bill savings for low-income families.[6]

[6] U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Methodological Framework for Analysis of GPRA Metrics: Application to FY04 Projects in BT and WIP*," PNNL 14231 (April 2003), pp. B-27–B-31. Because homes that are weatherized continue to save energy in the years following the weatherization, the total number of homes saving energy due to this program grows over time, even when program funding remains constant.

Environmental Benefits: Annual carbon dioxide emissions are projected to be 151 million metric tons (carbon equivalent) less than the 2020 baseline projection of 2,073 million metric tons, a reduction of about 7.5% (**Figure 3.4**) or 39% of the expected increase from 2005 to 2020. By 2010, the projected reduction will be about 39 million metric tons, which could provide about one-third of the targeted 2012 carbon reduction under President Bush's Climate Change Initiative.

Although not quantified here, EERE's portfolio also contributes toward improved regional and local air quality through reduced SO_2 and NOx emissions from fossil energy consumption (SO_2 reductions in the utility sector are likely to lower permit prices rather than reduce net emissions in this sector). The portfolio also provides state and local governments with additional options for meeting Clean Air Act ambient air quality standards. For instance, the Clean Cities activity in WIP facilitates local purchases of alternative-fuel vehicles.

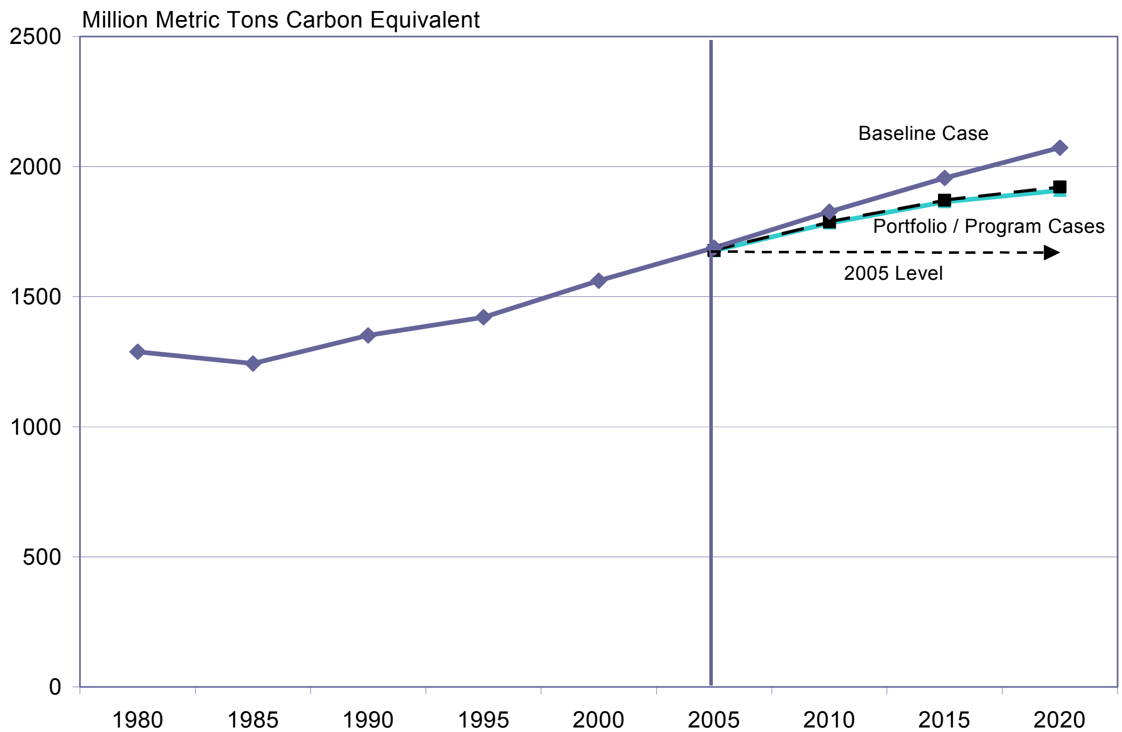

Figure 3.4. U.S. Carbon Dioxide Emissions, 1980-2000, and Projections to 2020: Baseline, Program, and Portfolio Cases

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 12.2, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

Security Benefits: The EERE portfolio is expected to reduce annual oil consumption by 3 quadrillion Btu from the 2020 baseline of 52 quadrillion Btu (**Figure 3.5**), or about 1.6 million barrels of oil per day (about 31% of expected growth in oil demand between 2005 and 2020).

While EERE's portfolio has elements that increase (as well as decrease) natural gas consumption; on balance, EERE's portfolio is expected to reduce annual natural gas

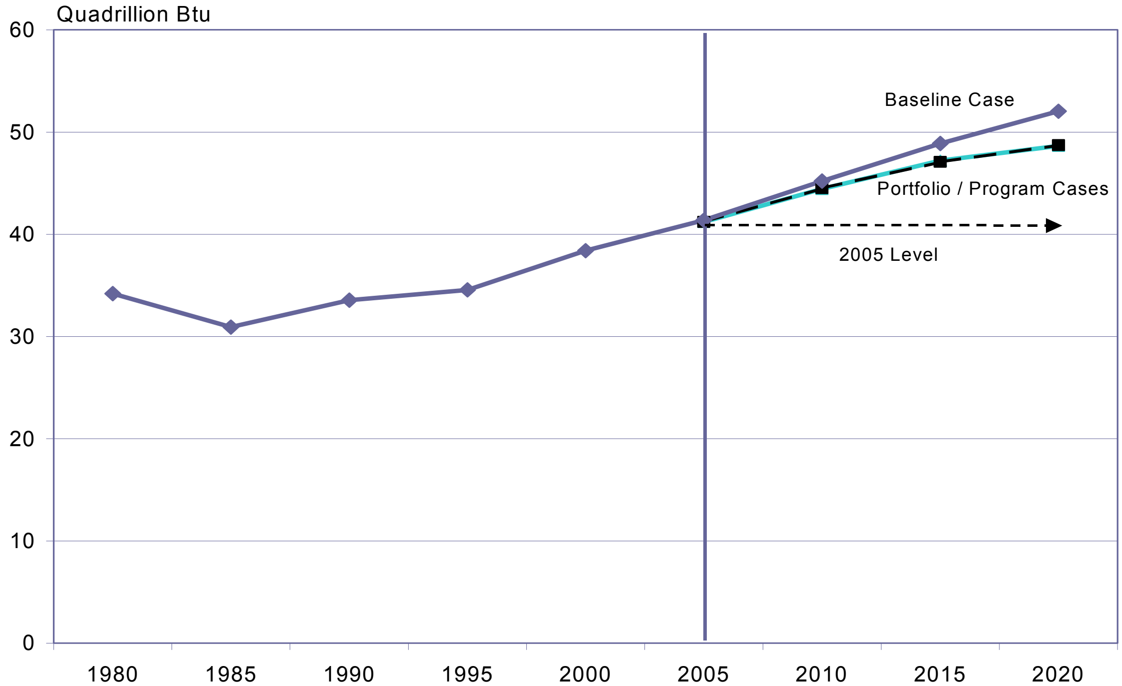

Figure 3.5. U.S. Oil Consumption, 1980-2000, and Projections to 2020: Baseline, Program, and Portfolio Cases

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

consumption by 4 quadrillion Btu from the baseline of 35 quadrillion Btu (**Figure 3.6**) in this time frame.[7] While EERE does not estimate the portion of natural gas savings attributed to imported natural gas supplies, supplies from countries other than the United States and Canada may be the marginal sources of natural gas for meeting any future growth in demand.

Capacity Benefits: When evaluated as part of a portfolio, energy efficiency improvements developed by EERE reduce the market opportunity for the development of new renewable resources by reducing the demand for additional energy capacity. Even with these reductions, EERE projects that renewable energy technologies will provide significantly larger electricity capacity additions than in the Baseline Case by 2020. As shown in **Figure 3.7**, renewable energy capacity additions are projected to grow by an additional 40 GW compared with the Baseline Case by 2020. Moreover, if some of these efficiency improvements fail to materialize, it is likely that they would be partly "backfilled" by the development of additional renewable energy resources. In addition, EERE's technology programs contribute to security of the Nation's electricity supplies in another important way: through the combination of reduced peak demand for electricity (through improved efficiency or when coincident with renewable generation) and the development of on-site electricity generation sources (to mitigate bottlenecks in the electricity transmission grid).

[7] The remaining chapter of this report describes some of the limitations and omissions in the current benefits analysis, which limit EERE's ability to reflect the full benefits for each EERE program.

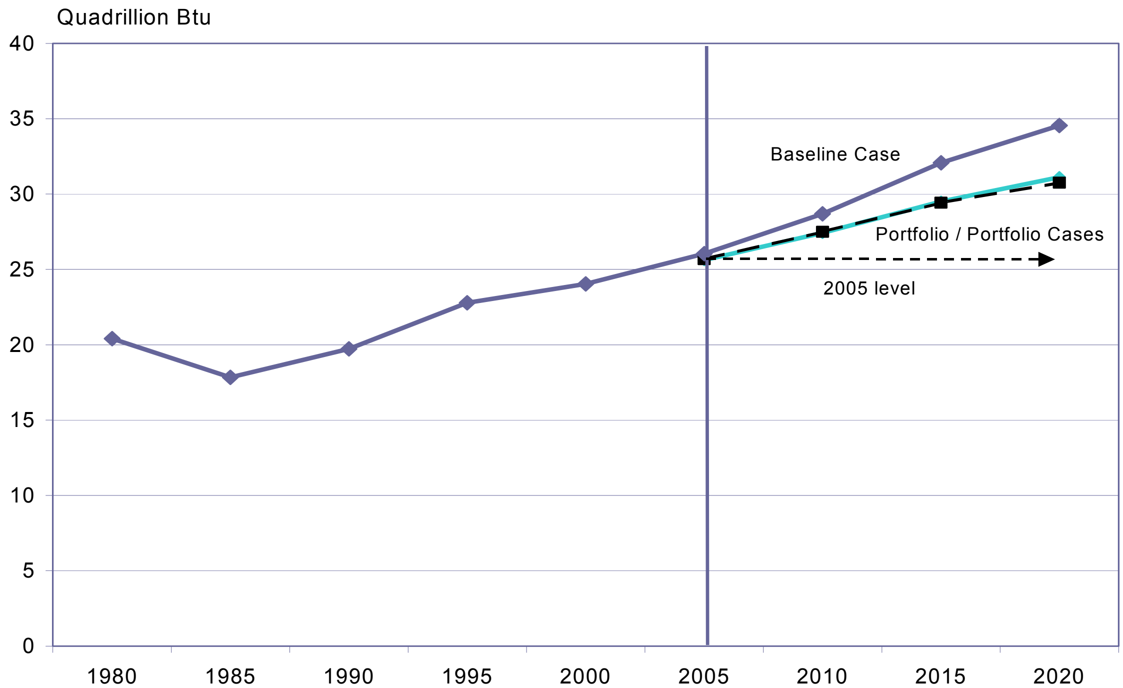

Figure 3.6. U.S. Natural Gas Consumption, 1980-2000, and Projections to 2020: Baseline, Program, and Portfolio Cases

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

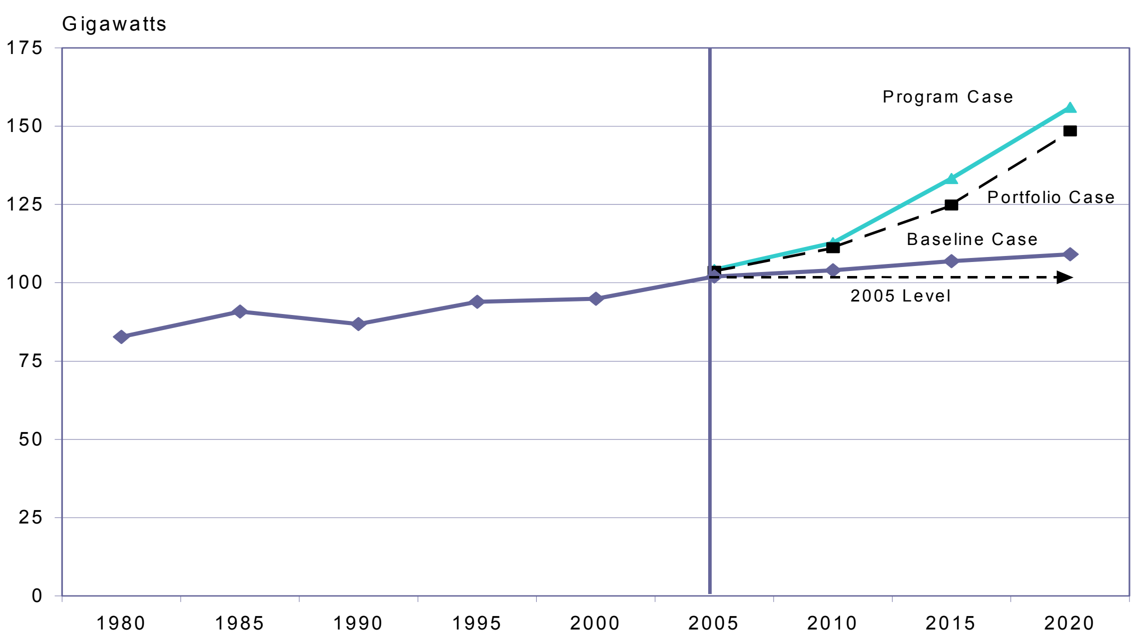

Figure 3.7. U.S. Renewable Energy Capacity, 1980-2000, and Projections to 2020: Baseline, Program, and Portfolio Cases

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Table 8.7a, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

Program Benefits

The remainder of this chapter is devoted to program-specific information, including program budgets and benefits. **Figure 3.8** displays the EERE program budgets for FY 2004. The largest program budget is $369 million for the WIP (Weatherization and Intergovernmental Program), which includes $284 for Low-Income Weatherization Assistance.

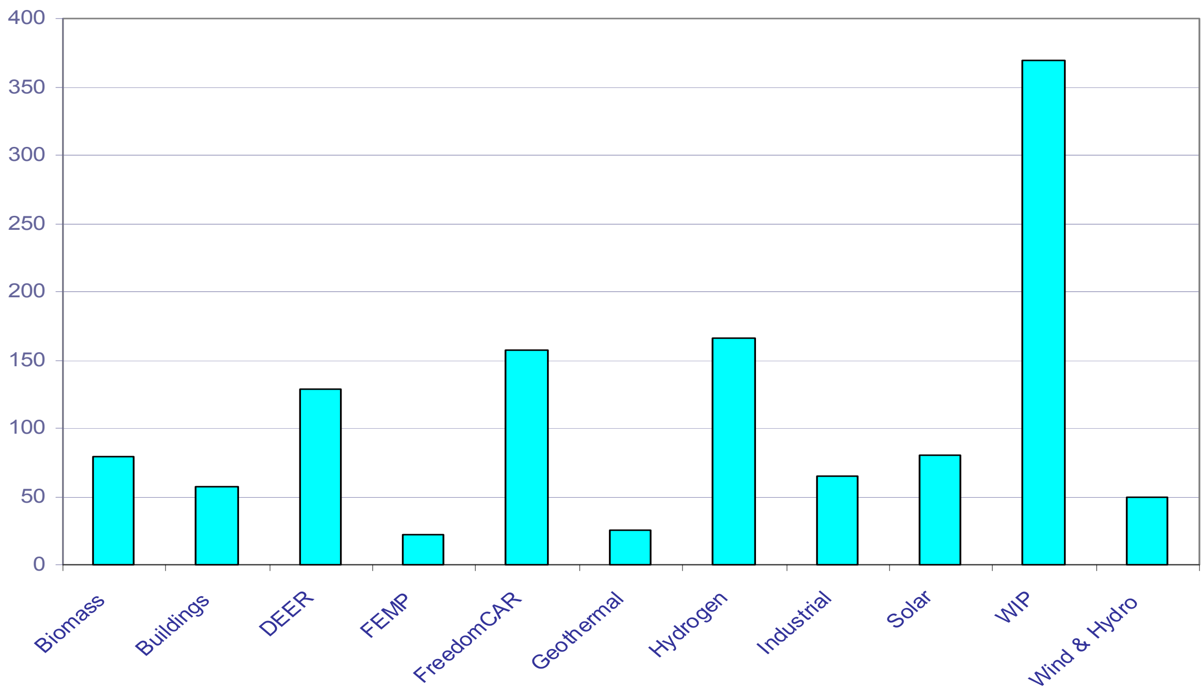

Figure 3.8. EERE Program FY 2004 Budget Requests (2000 dollars)

Source: 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.

The FY 2004 estimates of benefits for the individual EERE programs are shown for 2020 in **Figures 3.9 through 3.14**. The benefits vary widely across EERE's programs, with each program providing a different level and mix of types of benefits. Nonrenewable energy savings in 2020, for example, range from 0.07 quadrillion British thermal units (Btu) for the Federal Energy Management Program (FEMP) to 2.13 quadrillion Btu for the Industrial Technologies Program (**Figure 3.9**). The differences in benefits result from a number of factors: (1) program size and target market; (2) time frames for program results; (3) primary types of benefits addressed by each program; and (4) technical potential achievable within each program and the amount of improvement already included in the baseline. Note that these estimates do not reflect the relative technical or market risk associated with these program activities. In addition, in this transition year for EERE, not all programs were able to generate new performance goals indicating the years in which they expected each technology to be ready for market in time for this analysis. As a result, portions of some program benefits are not reflected in the estimates reported here.

Once a technology enters the market, benefits increase for some period of time as (1) market shares or sales grow; (2) total market size grows to reflect increased population or GDP; and (3) the existing stock of energy-using buildings and equipment is replaced in comparison to the expected improvement in the business-as-usual case.

EERE programs differ greatly in anticipated dates of commercialization, with those programs likely to generate market results in the near term showing the largest benefits during the 15 years addressed by this analysis. In several cases, such as hydrogen-based vehicles, EERE technologies are not expected to be available until about 2020, so it was not possible to include meaningful estimates of even initial benefits levels. Those programs with a larger number of early technology introductions are likely to exhibit larger benefits.

Several EERE programs are targeted toward benefits not well reflected in any of EERE's quantified benefits metrics. For instance, the Distributed Energy Resources (DER) Program focuses on improving electricity reliability by developing electricity-generating capacity at or near the point of use (**Figure 3.14**). However, EERE does not currently have the capability of quantifying the level or value of improved reliability, or of reflecting the consumer value for reliability in estimated future market purchases. Similarly, the State Energy Grant Program funds the development of State energy plans, including energy emergency planning. This key component of homeland security is not reflected in any of the security metrics in this analysis. In the case of the Biomass Program, there has been a substantial redirection of the research toward integrated biorefineries that will produce a mix of high-value chemicals, as well as fuels such as ethanol and electric power. These are very complex systems, and EERE does not yet have an adequate modeling capability for this, as described in **Chapter 4**.

While incomplete, 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.

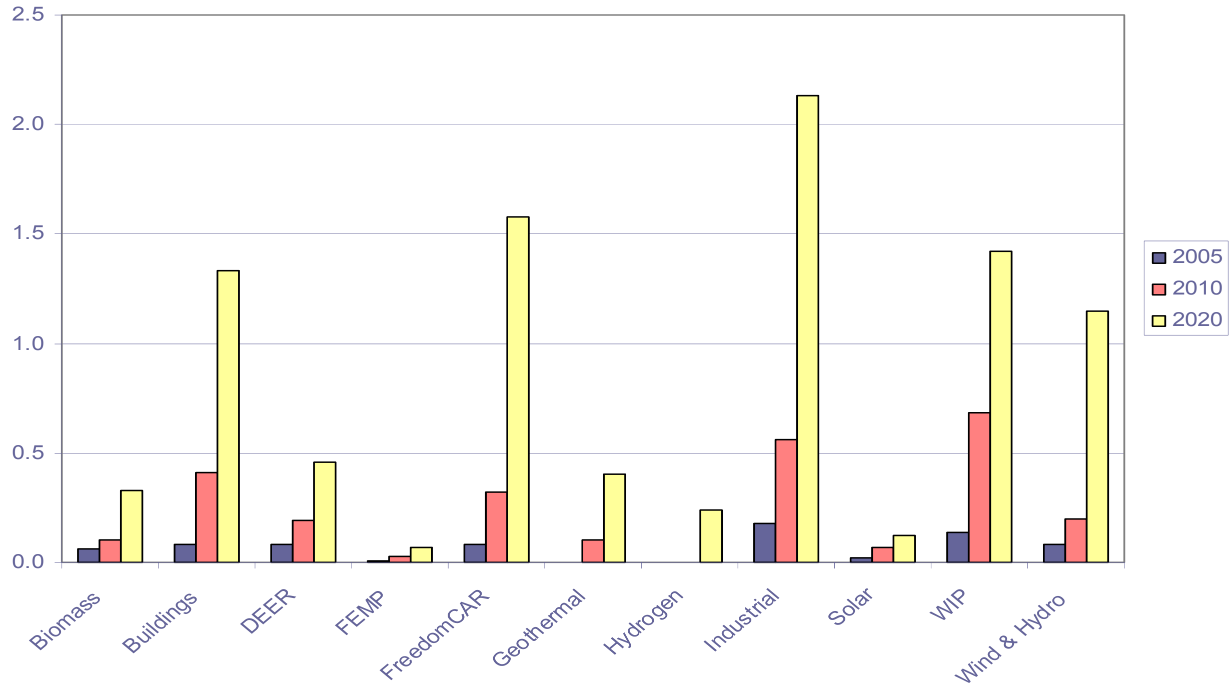

Figure 3.9. Annual Nonrenewable Energy Savings: 2005, 2010, 2020 (quadrillion Btu)

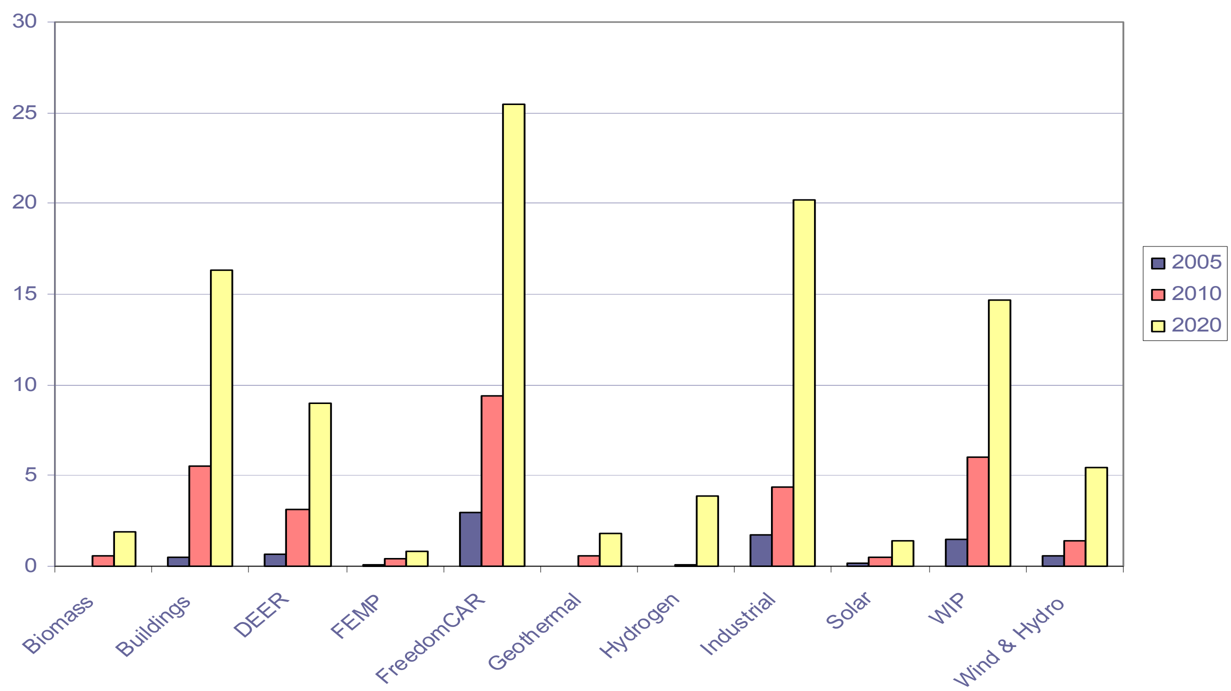

Figure 3.10. Annual Energy Expenditure Savings: 2005, 2010, 2020 (billion 2000 dollars)

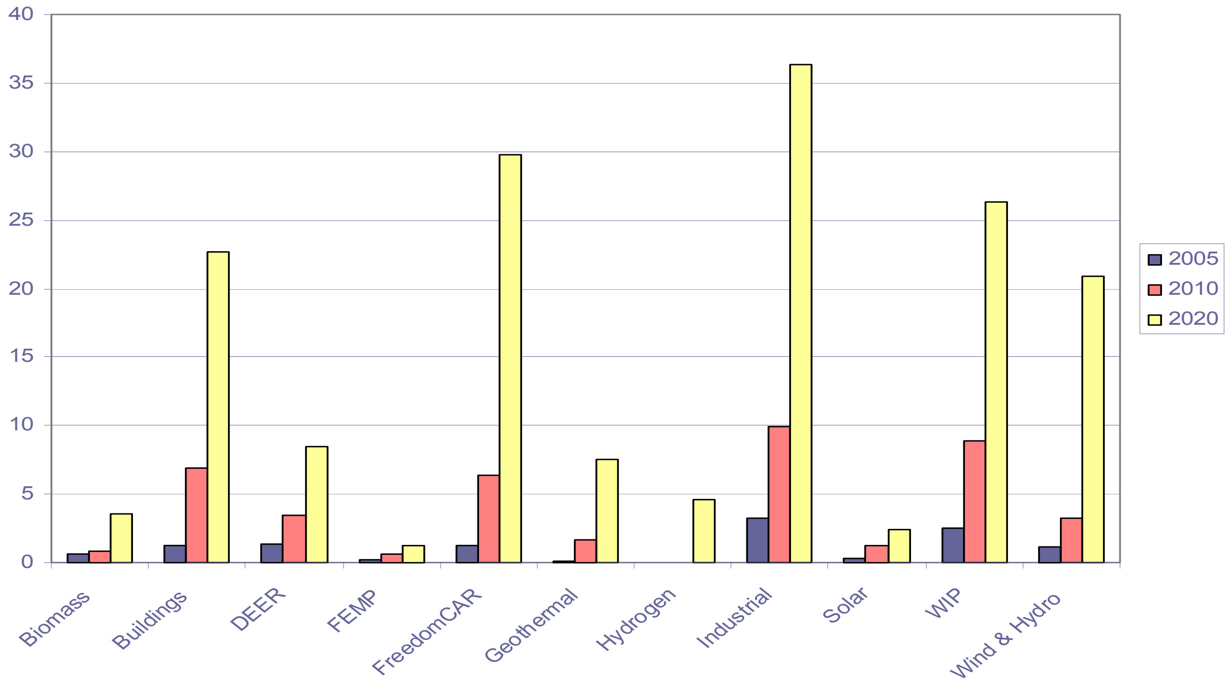

Figure 3.11. Annual Carbon Dioxide Savings: 2005, 2010, 2020 (mmt carbon equivalent)

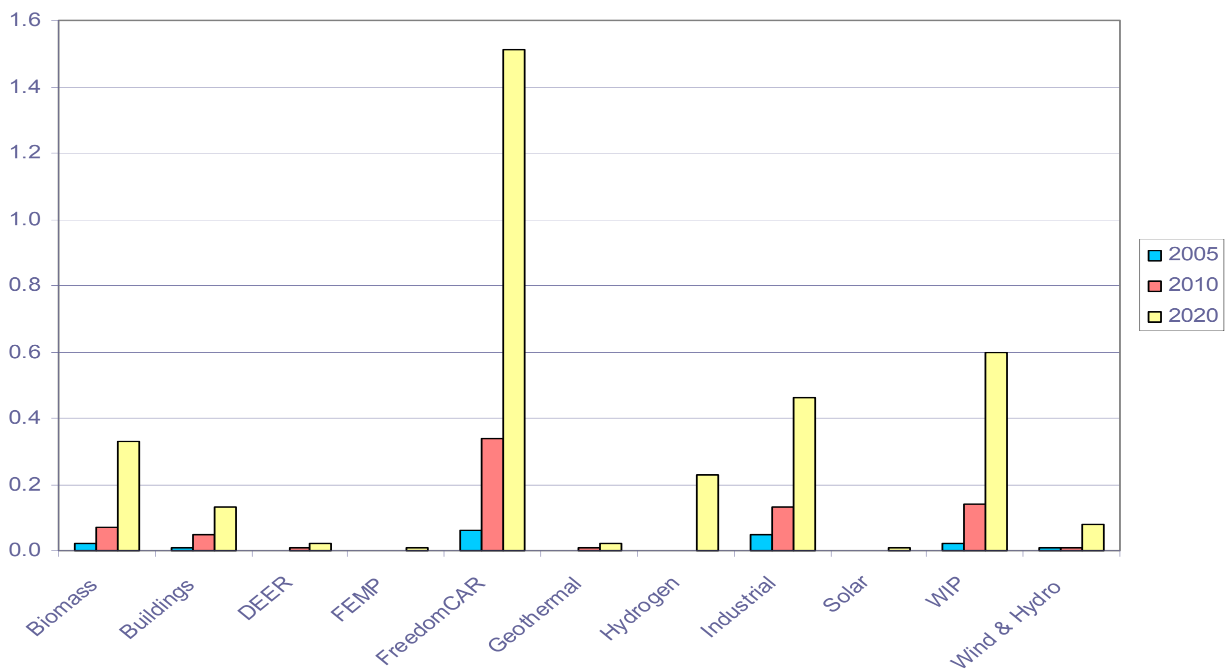

Figure 3.12. Annual Oil Savings: 2005, 2010, 2020 (quadrillion Btu)

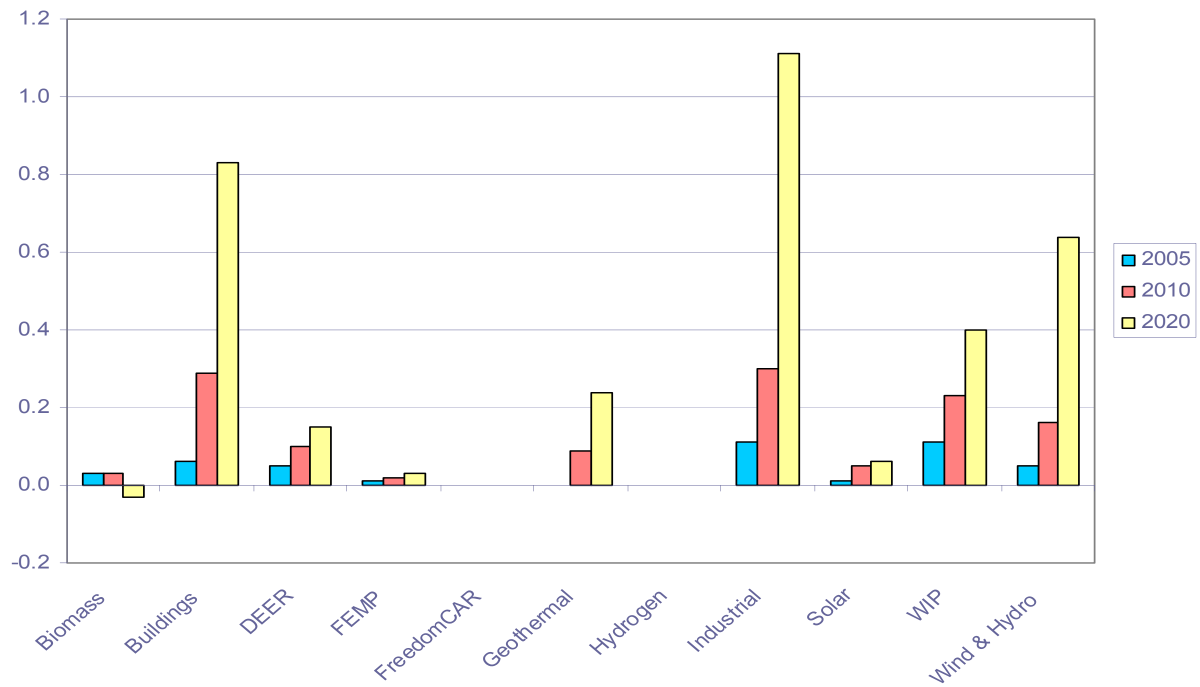

Figure 3.13. Annual Natural Gas Savings: 2005, 2010, 2020 (quadrillion Btu)

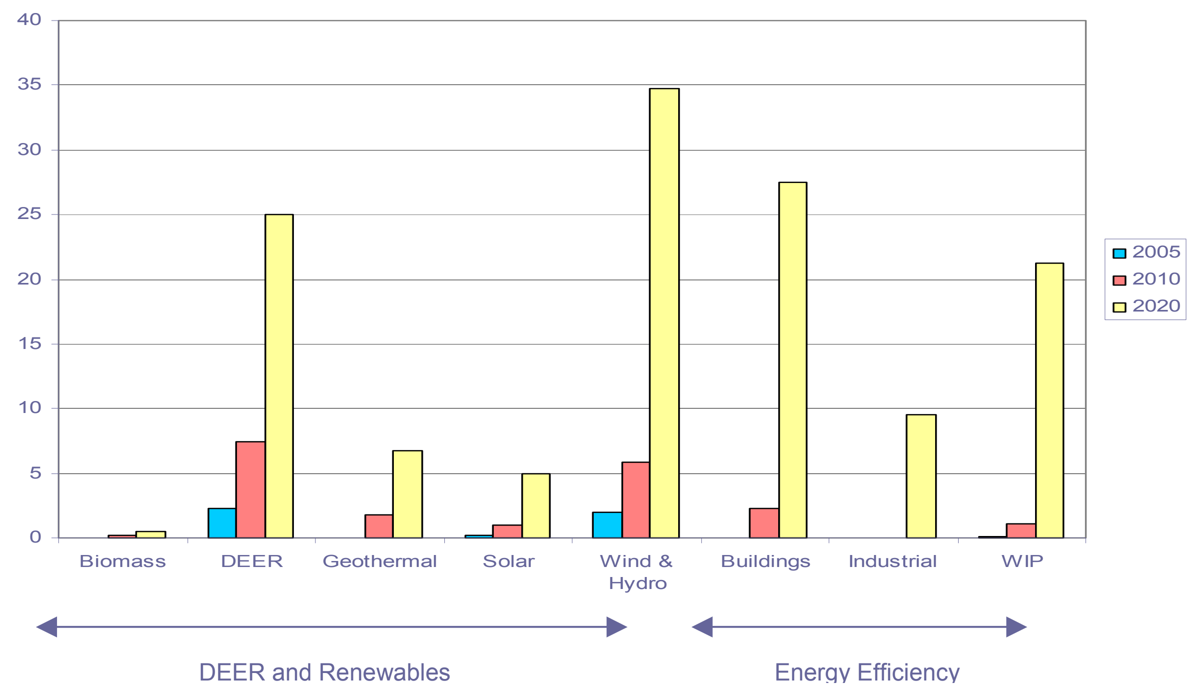

Figure 3.14. Annual Renewable Electric Capacity – Energy Efficiency, DEER, and Renewables: 2005, 2010, 2020 (gigawatts)

Note: The FEMP, Hydrogen, and FCTV programs either do not have renewable electric-capacity impacts or do not have measurable impacts in quads by 2020.