CHAPTER 2

MIDTERM BENEFITS ANALYSIS OF EERE'S PROGRAMS

Introduction

The anticipated outputs from the Office of Energy Efficiency and Renewable Energy (EERE) Research, Development, Demonstration, and Deployment (RD3) programs are represented in NEMS-GPRA07 in the Individual Program Goal Cases and Portfolio Cases to estimate the midterm (to 2025) benefits for each program and for EERE's overall portfolio. This chapter describes the NEMS-GPRA07 analyses for each program. The appendices provide additional information on the inputs provided by each program.

Table 2.1 shows a breakdown by program of the two types of analytical tools employed in its benefits analyses—specialized "off-line" tools and NEMS-GPRA07. A description of the Energy Information Administration's (EIA) National Energy Modeling System (NEMS) model is provided in **Box 2.1** at the end of this chapter.[1] Off-line tools are those used to develop input for NEMS and, in some cases, to estimate benefits for program activities outside of the scope of NEMS. Descriptions of the off-line tools are provided in the related program appendices.

Table 2.1. Program Benefits Modeling by Primary Type of Model Used and Activity Area

Program	Activity Area	Off-Line Tool	NEMS-GPRA07
Biomass	Ethanol from Corn Fiber and Residual Starch		✓
	Cellulosic Ethanol		✓
Building Technologies	Technology R&D	✓	✓
	Regulatory Actions	✓	✓
	Market Enhancement	✓	
FEMP	FEMP	✓	
Hydrogen, Fuel Cells, and Infrastructure Technologies	Fuel Cells		✓
	Production and Delivery	✓	
Industrial Technologies	Industrial programs	✓	
Solar Energy Technologies	Photovoltaic Systems	✓	✓
	Concentrated Solar Power		✓
Vehicle Technologies	Light Vehicle Hybrid and Diesel		✓
	Light-weight Materials for LDVs		✓
	Heavy Vehicles	✓	
Weatherization and Intergovernmental	Weatherization	✓	
	Domestic Intergovernmental	✓	
Wind and Hydropower Technologies	Wind		✓

Required off-line analysis using specialized off-line tools can range from simple verification of program goals to an initial calculation of energy savings, depending on the treatment of the target market in NEMS-GPRA07 and the nature of the program. The activity areas listed in **Table 2.1**

[1] For more detailed information about NEMS, see http://www.eia.doe.gov/bookshelf/docs.html for individual reports documenting the NEMS modules.

are groupings of activities within each program that share either technology or market features—they do not represent actual program-management categories.

Biomass Program

The goal of the Biomass Program is the development of biomass refineries (biorefineries), which produce multiple products, including at least one energy product. Energy products include ethanol, other fuels, and electricity. Non-energy products include chemicals and materials. The biorefinery concept allows the cost of production to be reduced through synergies associated with feedstock handling and processing, and the allocation of capital and fixed O&M costs across multiple products. The current analysis is based on biorefineries that produce ethanol fuel as a major output along with specialized bioproducts.[2]

Corn-based ethanol: The primary thrusts of the R&D related to corn-based ethanol production are the use of corn kernel fiber and residual starch in dry mills that will increase ethanol yields per bushel of corn, and the development of bio-based chemical coproducts. These goals are represented within the NEMS-GPRA07 framework through modifications in the corn ethanol yields, and per unit O&M and capital costs. The production of bio-based chemicals is treated as a revenue credit for the ethanol. The Biomass Program assumes that these same improvements would occur without the EERE R&D, but would be delayed by seven years. The program's goal is to begin to deploy the technology in 2012 and assumes a seven-year phase-in for implementation. Therefore, 2019 is the first year of deployment in the Base Case.

There were also several modifications made to the NEMS-GPRA07 representation of corn ethanol production with NEMS-GPRA07. The NEMS supply curves from the *AEO2005* were expanded to allow up to 10 billion gallons of production by assuming the same slope as in the AEO's feedstock corn prices and raising the last step of production. In addition, the base ethanol yields and credit for distillers' dry grains (DDG), an animal feed material that is the coproduct of dry mills, were increased from those in the *AEO2005* and are closer to those in the just-released AEO2006.[3] Note that, because NEMS-GPRA07 is based on the *AEO2005* reference case, the Baseline Case does not include new policies from EPACT that are reflected in *AEO2006*, such as the implementation of a renewable fuel standard that mandates increased use of ethanol up to a level of 7.4 billion gallons per year in 2012.

Cellulosic ethanol from biorefineries dedicated to the production of ethanol and lignin-derived electricity: EERE is sponsoring research aimed at reducing the cost of producing ethanol from cellulosic biomass.[4] The cellulosic biorefineries modeled in this analysis are ones that focus on producing ethanol and lignin-derived electricity.[5] The program goal, as alluded to

[2] Future analyses could include additional fuels that the program may identify in the longer term. In addition, the research undertaken to improve the harvesting of agricultural residue feedstocks has not been included in the GPRA analysis.
[3] Unfortunately, the timing of AEO's release does not afford our program analysts and energy modelers the time to run our GPRA benefits analyses with the most recent AEO.
[4] Cellulose and hemicellulose that can be converted to ethanol (and other chemicals, materials, and biofuels) are found in biomass such as agricultural residues (corn stover, wheat, and rice straw), mill residues, organic constituents of municipal solid wastes, wood wastes from forests, future grass, and tree crops dedicated to bio-energy production.
[5] In the future, when designs of alternative biorefinery configurations (e.g., those producing ethanol, electricity, and bio-based chemicals) are available, the benefits analysis will include such concepts as well.

in the President's Advanced Energy Initiative,[6] is to achieve a production cost of $1.07 per gallon of ethanol by 2012, with cost reductions in subsequent years. In NEMS-GPRA07, the commercialization date was set to 2015 to allow for three years from pilot to start-up of a full commercial facility. Cellulosic production capacity is assumed to be able to expand at a rate of 500 million gallons, or by 25% per year (whichever is greater), consistent with growth constraints based on historical data of the highest existing corn ethanol industry and gasoline-refinery capacity expansion rates.

In NEMS-GPRA07, the capital costs, non-fuel operating costs, and conversion efficiencies for cellulosic ethanol were modified to reflect the program targets for the Individual Program Goal Case. The biomass feedstock curves in NEMS-GPRA07 are used to determine the feedstock price by region and year. In the Baseline, cellulosic ethanol production is assumed to penetrate after the NEMS time horizon to 2025.

The refinery model within NEMS-GPRA07 evaluates the use of ethanol as a blending agent for gasoline, taking into account its chemical properties as well as its energy value. As ethanol becomes less expensive due to advanced technologies, more ethanol is used. In both the Baseline and Individual Program Goal Cases, corn ethanol reaches its peak of 10 billion gallons per year by 2025. Cellulosic ethanol grows from its introduction in 2015 to 7.3 billion gallons in 2025. The refinery model also produces E85, for which production levels are dependent on the relative attractiveness of its use primarily in flex-fuel vehicles.

The Biomass Program benefits shown in **Table 2.2** are the reductions in energy use and carbon emissions in the Individual Program Goal Case compared with the Baseline Case.[7]

Table 2.2. FY07 Annual Benefits Estimates for Biomass Program (NEMS-GPRA07)

Benefits	**2010**	**2015**	**2020**	**2025**
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	ns	0.27	0.36	0.39
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	ns	ns	7.7	5.4
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	ns	6	6	7
Security				
Oil Savings (million barrels per day)	ns	0.20	0.27	0.22
Natural Gas Savings (quadrillion Btu/yr)	ns	-0.14	-0.10	ns
Avoided Additions to Central Conventional Power (cumulative gigawatts)	ns	ns	ns	ns
Other Program Metrics				
Incremental Ethanol Production (billion gallons/yr)	0.00	5.2	7.8	7.3

[6] For more details on the Advanced Energy Initiative, see http://www.whitehouse.gov/stateoftheunion/2006/energy/index.html
[7] Note that in the Biomass Individual Program Goal Case, the advanced transportation technologies available in Freedom Car and Vehicle Technologies Individual Program Goal Case are unavailable, despite the market synergies of the two suites of technologies. In the EERE portfolio case, both suites are modeled.

More information about the assumptions underlying the Biomass Program's benefits analysis can be found in **Appendix C**.[8]

Building Technologies Program

The activities of the Building Technologies Program can be classified into three general types: technology R&D, regulatory actions, and market enhancement. The modeling approach and applicable end uses for the activities that comprise the Building Technologies Program are shown in **Table 2.3**. Analysts model the technology R&D activities by modifying costs and efficiencies of the equipment and shell-technology slates. Market-enhancement activities and some regulatory activities (such as buildings codes) are modeled using penetration rates and energy-savings estimates.

Table 2.3. Modeling Approach for Building Technologies Program Activities

	Sector		End-Use					Modeling Approach		
Building Technology Project List	Resd	Comm	Heat	Cool	Water Heating	Lighting	Other	Energy Savings and Penetration Rates	Equipment Technology Costs and Efficiencies	Shell Technology Costs and Efficiencies
Residential Buildings Integration										
Research and Development (Building America)	✓		✓	✓	✓	✓	✓			✓
Residential Building Energy Codes	✓		✓	✓				✓		
Commercial Buildings Integration										
Commercial Research and Development		✓	✓	✓						✓
Commercial Building Energy Codes		✓	✓	✓		✓		✓		
Analysis Tools and Design Strategies		✓	✓	✓						✓
Refrigeration/Space Conditioning R&D										
Thermotunneling Based Cooling	✓	✓	✓	✓					✓	
HyPak-MA		✓		✓					✓	
Integrated Heat Pump	✓		✓	✓	✓				✓	
Building Envelope R&D										
Electrochromic Windows		✓	✓	✓		✓				✓
Superwindows	✓		✓	✓				✓		✓
Low-E Market Accpetance	✓	✓	✓	✓				✓		
Advanced Wall Systems	✓		✓	✓						✓
Next Generation Attic Systems	✓		✓	✓						✓
Next Generation Envelope Materials	✓		✓	✓						✓
Lighting Research and Development										
Lighting Controls		✓				✓		✓		
Solid State Lighting	✓	✓				✓			✓	
Appliances and Emerging Technologies										
SSL Market Acceptance	✓	✓							✓	
Standards										
HID lamps		✓				✓			✓	
Electric Motors, 1-200 HP		✓					✓	✓		
Distribution Transformers								✓		
Rebuild America		✓						✓		
Energy Star										
Compact Fluorescents	✓					✓		✓		
Windows	✓		✓	✓				✓		
Refrigerators	✓						✓	✓		
Dishwashers	✓						✓	✓		
Clotheswashers	✓						✓	✓		
Room AC	✓			✓				✓		
Home Performance	✓		✓	✓				✓		

[8] More information about the relevant NEMS modules may be found at http://tonto.eia.doe.gov/FTPROOT/modeldoc/m059(2005)-1.pdf (Petroleum Market Module, volume 1), http://tonto.eia.doe.gov/FTPROOT/modeldoc/m059(2005)-2.pdf (Petroleum Market Module, volume 2), http://tonto.eia.doe.gov/FTPROOT/modeldoc/m070(2005).pdf (Renewable Fuels Module) and http://tonto.eia.doe.gov/FTPROOT/modeldoc/m069(2005).pdf (Transportation Sector Demand Module).

Technology R&D: The technology R&D activities seek to develop new or improved technologies that are more energy efficient and more cost-effective than the alternatives currently available. The projected benefits for these are measured by modifying the technology slates from those that are available in the Baseline Case to reflect the program goals. Building technologies in NEMS-GPRA07 are represented by end use. For most end uses, there are conversion technologies (e.g., furnaces and water heaters) that use different fuels and that have several different levels of energy efficiency. The Baseline Case incorporates EIA's estimation of future technology improvement. The rate of technology improvement is modified in the Individual Program Goal Case.

Residential shell technologies (such as windows or insulation) for new buildings are represented by several combinations or "packages" of technologies with different levels of improvements. Each package is characterized by a capital cost, and heating and cooling load reductions. The commercial-sector shell measures are represented by window and insulation technologies that can be selected individually. EIA developed the residential methodology for the *AEO2001*, while OnLocation developed the commercial methodology for EERE.

The residential and commercial sectors are each represented by several building types within nine Census divisions. NEMS-GPRA07 computes the end-use technology choice for each of these building types and geographic regions, based on the relative economics and estimations of consumer behavior for the technologies. The latter is important to replicate current technology market shares.

In a few cases where NEMS-GPRA07 has insufficient detail for explicit technology representation, analysts computed market penetration using off-line tools, and the results were implemented with NEMS-GPRA07 through efficiency factors.

Regulatory activities: Regulatory activities include setting new appliance standards—based on the legislatively mandated schedule—and encouraging state adoption of more stringent building codes. Modeling appliance standards is straightforward. In the year that the program expects the new standard to be implemented, all technologies that are less efficient than the standard are removed from the market and unavailable for consumer choice. The resulting energy savings depend on the difference in the level of efficiency of the standard compared to the technology that had been selected in the Baseline Case. The exception are distribution transformers that are not explicitly represented in the model, so off-line estimates of electricity savings are used to decrease the transmission and distribution losses.

Market enhancement: Building-code development is primarily a regulatory activity, although it also involves outreach to encourage the various states to adopt new and stricter standards. Analysts make a spreadsheet computation of average savings using off-line estimates for the fraction of buildings within areas that adopt more stringent codes, as well as the heating, cooling, and lighting load reductions associated with the new levels of codes. For residential buildings, the savings are based on increased compliance with existing codes, accelerated adoption of the 2000 edition of the International Energy Conservation Code, and the future development of more stringent building codes. For commercial buildings, savings are based on increased stringency from the combined impact of the latest forthcoming ASHRAE code and the next-generation code assumed to be published in 2007. These analyses were performed at the State level to reflect the current variation in building codes and climate factors. The resulting savings were then represented in NEMS-GPRA07 through modification of the building shell efficiencies.

Energy Star aims to accelerate the market penetration of existing high efficiency technologies by providing greater information to consumers about their benefits and life-cycle operating savings. This is equivalent to lowering consumers' hurdle rates for investment in energy-efficient appliances. Therefore, analysts represented the Energy Star activities by modifying the NEMS-GPRA07 consumer-behavior coefficients, indicating how consumers trade first-cost expenditures for annual energy savings. The program goals for market penetration were used to determine the degree of change of these parameters. For most Energy Star appliances, the program goal is to reach a 20% market share for the more efficient Energy Star appliances.[9]

The Building Technologies Program results in energy savings primarily in four end-use categories: space heating, space cooling, water heating, and lighting. **Table 2.4** demonstrates the level of delivered energy savings (excluding losses from electricity generation) from each category. In 2025, space heating and lighting end uses have the highest delivered energy savings in residential buildings; while the lighting energy-use reduction is the largest in commercial buildings.

Table 2.4. Building Technologies Program Delivered Energy Savings by End Use

Energy Savings by End-Use (Quads)	Residential Sector				Commercial Sector			
	2010	2015	2020	2025	2010	2015	2020	2025
Space Heating	0.02	0.13	0.22	0.33	0.00	0.02	0.04	0.08
Space Cooling	0.00	0.03	0.06	0.11	0.00	0.02	0.04	0.11
Water Heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lighting	0.01	0.02	0.05	0.17	0.00	0.02	0.05	0.21
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	0.18	0.32	0.60	0.01	0.06	0.13	0.40

The Building Technologies Program benefits (**Table 2.5**) are estimated within the integrated NEMS-GPRA07, so that the electricity-generation primary energy savings are directly computed. In addition, the estimates include any feedbacks in the buildings or other sectors resulting from changes in energy prices that result from the reduced energy consumption.

[9] Energy Star is a cooperative effort between DOE and the Environmental Protection Agency. There is a division of responsibilities with respect to specific technologies, and EERE claims benefits for the penetration of the technologies for which it is responsible. Nevertheless, some of the general campaigns and marketing strategies are joint efforts between the agencies, and attribution of the benefits to DOE or EPA is difficult.

Table 2.5. FY07 Annual Benefits Estimates for Building Technologies Program (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	0.10	0.41	0.81	1.99
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	1.2	7.7	16.5	17.3
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	2	8	17	45
Security				
Oil Savings (million barrels per day)	ns	0.02	0.09	0.04
Natural Gas Savings (quadrillion Btu/yr)	0.05	0.25	0.23	0.48
Avoided Additions to Central Conventional Power (gigawatts)	ns	9	26	62
Other Program Metrics				
Total Electricity Capacity Avoided (cumulative gigawatts)	ns	13	32	76

More detail about the assumptions underlying the Building Technologies Program's benefits analysis can be found in **Appendix G**.[10]

Federal Energy Management Program

The Federal Energy Management Program (FEMP) is an implementation program to increase the energy efficiency of Federal Government buildings, which account for about 5% of U.S. commercial-building energy consumption. FEMP activities support the installation of a variety of existing technologies, rather than focusing on the development of specific technologies, as do many other EERE programs. Because it encompasses a broad technological scope—while, at the same time, targets a specific market segment—FEMP is difficult to model in an integrated framework such as NEMS-GPRA07. However, there is also less uncertainty associated with achieved energy savings, because the program tracks changes in Federal energy consumption.

Delivered energy savings (estimated off-line) are used as inputs for the integrated modeling. These projected savings are subtracted from the Baseline Case for commercial-building energy consumption. Analysts use the model to compute the other benefits metrics of primary energy savings, carbon emission reductions, and energy-expenditure savings (**Table 2.6**).

[10] More details about the relevant NEMS modules may be found at:
http://tonto.eia.doe.gov/FTPROOT/modeldoc/m067(2005).pdf (Residential Sector Demand Module) and
http://tonto.eia.doe.gov/FTPROOT/modeldoc/m066(2005).pdf (Commercial Sector Demand Module).

Table 2.6. FY07 Annual Benefits Estimates for FEMP (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	0.01	0.01	0.02	0.02
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	0.1	0.1	0.1	0.2
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	0.2	0.2	0.3	0.4
Security				
Oil Savings (million barrels per day)	ns	ns	ns	ns
Natural Gas Savings (quadrillion Btu/yr)	ns	0.01	0.01	0.01
Avoided Additions to Central Conventional Power (cumulative gigawatts)	ns	ns	ns	ns

More detail on the Federal Energy Management Program's benefits analysis can be found in **Appendix I**.[11]

Hydrogen, Fuel Cells, and Infrastructure Technologies Program

The Hydrogen, Fuel Cells, and Infrastructure Technologies Program is targeted toward the introduction of fuel cells for both stationary and vehicular applications, as well as the production and delivery of hydrogen at a reasonable price. NEMS-GPRA07 does not have a representation of hydrogen-supply options.[12] Therefore, we employ a simplifying assumption that all hydrogen produced through 2025 would be derived from natural gas. The hydrogen conversion process is assumed to be 75% efficient and yield a hydrogen price of $2 per gallon of gasoline equivalent (excluding taxes) when the natural gas price is $5 per MMBtu.

The stationary fuel cell research is focused on distributed proton-exchange membrane (PEM) fuel cells. The program goals for their capital costs and efficiencies were taken from the multiyear program plan (MYPP). The MYPP provides goals through 2010, and no further improvements were assumed. This conservative assumption most likely understates the benefits of these fuel cells. Analysts converted program technology goals into installed costs for combined heat and power systems in residential and commercial buildings.

The fuel cell vehicles were modeled along with the Vehicle Technologies Individual Program Goal Case. The success of fuel cell vehicles is predicated on some of the vehicular improvements being developed under the Vehicle Technologies Program, so the fuel cell vehicles could not be treated in isolation. Analysts modified the gasoline and hydrogen fuel cell vehicle costs and efficiencies to reflect the program goals (see the Vehicle Technologies Program description for more detail about the modeling of vehicle choice). In addition, hydrogen was assumed to be available for vehicle refueling at 10% of vehicle refueling stations by 2020 and available at 25 percent of refueling stations by 2025. The benefits associated with fuel cell vehicles were derived by comparing the number of fuel cell vehicles projected in the case in which both Hydrogen and Vehicle Technologies were evaluated to the number of fuel cell vehicles projected

[11] More details about the relevant NEMS module may be found at http://tonto.eia.doe.gov/FTPROOT/modeldoc/m066(2005).pdf (Commercial Sector Demand Module).
[12] Hydrogen is represented within the refinery model of NEMS-H2, but for internal use only.

in the case with Vehicle Technologies only. Analysts computed energy savings, oil savings, and carbon emission reductions, based on the relative fuel and carbon emissions per mile of the incremental fuel cell vehicles relative to those in the Baseline. This approach leads to greater savings than would a simple difference between the Baseline and Individual Program Goal Cases, while still yielding smaller savings than would be derived by comparing a fuel cell vehicles case with the Baseline Case. **Table 2.7** presents the overall benefits.

Table 2.7. FY07 Annual Benefits Estimates for Hydrogen, Fuel Cells, and Infrastructure Technologies Program (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	ns	ns	0.02	0.22
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	ns	ns	ns	2.4
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	ns	ns	ns	6
Security				
Oil Savings (million barrels per day)	ns	ns	0.03	0.28
Natural Gas Savings (quadrillion Btu/yr)	ns	ns	-0.03	-0.33
Avoided Additions to Central Conventional Power (gigawatts)	ns	ns	ns	ns
Other Program Metrics				
Program-Specific Electric Capacity Additions (Cumulative gigawatts)	ns	ns	ns	ns

More details about the HFCIT Program's benefits analysis can be found in **Appendix B**.[13]

Industrial Technologies Program

The Industrial Technologies Program seeks to increase energy efficiency in the energy-intensive basic materials processing industries, as well as some key technologies that are common across most industries. The heterogeneity of the program makes it difficult to represent the program activities explicitly through technologies in the NEMS-GPRA07 framework. Therefore, analysts perform an off-line analysis using detailed spreadsheet models, and use the resulting energy savings by fuel type to provide inputs into the integrated model. Analysts then run the fully integrated NEMS-GPRA07 to compute the benefits metrics of primary energy savings, carbon emission reductions, and energy-expenditure savings that are associated with the fuel-consumption reductions.

At the time of publication of the Congressional Budget request, out-year funding profiles for a number of programs within DOE's FY 2007 Congressional Budget Request were not yet complete. In such instances, EERE assumed "steady-state" funding trajectories to calculate benefits estimates, pending further information. Now that "target" funding allocations have been finalized, the estimates shown here for the Industrial Technologies Program reflect DOE's decision to conclude this program after FY 2008. The benefits decline after 2010, due to the

[13] More details about the relevant NEMS modules can be found at http://tonto.eia.doe.gov/FTPROOT/modeldoc/m070(2005).pdf (Transportation Sector Demand Module), http://tonto.eia.doe.gov/FTPROOT/modeldoc/m067(2005).pdf (Residential Sector Demand Module), and http://tonto.eia.doe.gov/FTPROOT/modeldoc/m066(2005).pdf (Commercial Sector Demand Module).

cessation of EERE R&D and the assumption that the program accelerates the adoption of efficient technologies—but that the private sector will eventually adopt at a later time even in the absence of the program.

Table 2.8. FY07 Annual Benefits Estimates for Industrial Technologies Program (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	0.03	0.03	ns	ns
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	0.4	0.2	ns	ns
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	0.7	0.5	ns	ns
Security				
Oil Savings (million barrels per day)	ns	ns	ns	ns
Natural Gas Savings (quadrillion Btu/yr)	0.01	0.01	ns	ns

More details about the Industrial Technologies Program's benefits analysis can be found in **Appendix H**.[14]

Solar Energy Technologies Program

The Solar Energy Technologies Program develops two electric-solar technologies. Photovoltaics (PVs) are being improved for both distributed and central electricity generation applications, and the program is working to accelerate PV adoption through the Solar America Initiative. The concentrated solar power (CSP) R&D activity develops better technology for large-scale central electricity generation facilities that concentrate solar energy to produce electricity through a thermal process.

Photovoltaic Systems: Several changes were made to the representation of distributed PV systems in the Baseline. The size of the typical distributed PV installation was increased to 4 kW per home (from 2 kW) and to 100 kW per commercial building (from 25 kW) to reflect literature on recent installations. The California renewable energy credit program, which provides a PV credit of $4,000/kW in 2003 (declining by $400/kW per year), was included for the Pacific region. The recently passed Federal tax credit was not included, because the legislation occurred after this analysis was performed.

In addition, the adoption rates of distributed technologies in commercial buildings were modified to reflect market data gathered by the EERE on consumer adoption of energy efficiency projects as a function of payback time (**Figure 2.1**).[15] The NEMS-GPRA07 framework uses a cash-flow model to evaluate the distributed energy (DE) technologies—combined heat and power (CHP) and photovoltaic (PV) systems—within the building sectors. For commercial buildings, debt and interest payments are computed over a loan period of 15 years, along with associated taxes and

[14] Details about the relevant NEMS module can be found at: http://tonto.eia.doe.gov/FTPROOT/modeldoc/m064(2005).pdf (Industrial Demand Sector Module).
[15] *Market Trends in the U.S. ESCO Industry: Results from the NAESCO Database Project*. Goldman, C., J. Osborn and N. Hopper, LBNL, and T. Singer, NAESCO, May 2002, LBNL-49601.

tax benefits and assuming a 25% down payment. Annual fixed maintenance costs also are included. The value of the electricity produced is then subtracted from these costs to determine the cash flow. The number of years until positive cash flow is reached determines the market share in new buildings. The annual market share for existing buildings is assumed to be a fraction of the share for new.

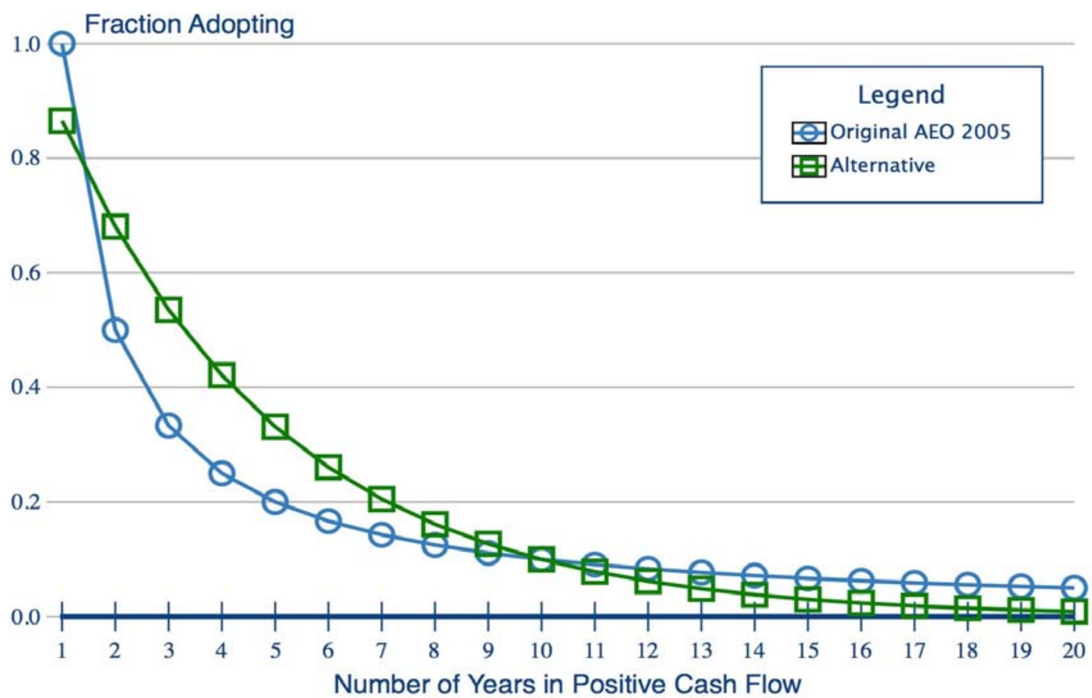


Figure 2.1. Commercial-Sector DG Adoption Rates

Under both the EIA and program assumptions, market share in new buildings decreases sharply as the number of years required to achieve positive cash flows increases. This reflects the high rates of return generally expected for energy-related projects by commercial-building owners. These shares apply to the fraction of commercial buildings assumed to be eligible for an installation of PV systems. The fraction of eligible buildings was increased from 30% to 60% for homes and to 55% for commercial buildings. These adoption-rate changes were made in the Baseline Case as well as the Individual Program Goal Case. In addition, the average-size building for commercial PV installations was modified from being four times the average size (as in the *AEO2005*) to being only twice as large. At this size, the PV-produced electricity is roughly equivalent to the annual electricity demand of the building.

The *AEO2005* Reference Case includes significant PV technological advancement. The GPRA07 Baseline was developed assuming that private industry would continue to improve first-generation PV (crystalline silicon) technology, but would not invest significantly on its own in second- or third-generation PV (thin-film, etc.) technologies in the absence of continued EERE programs. For the Individual Program Goal Case, the capital and O&M costs were modified to reflect the program's goals. The regional capacity factors in the Baseline Case were similar to those in the program's goals, so they were left unchanged.

In addition to competing on an economic basis with other electricity-generation technologies, PV may be constructed for its environmental benefits. For example, the Solar Program's Solar America Initiative goals were incorporated as planned distributed-PV capacity additions in NEMS-GPRA07.

Table 2.9. NEMS-GPRA07 Projected Solar Capacity (GW)

Solar Generation Technologies

	2010	2015	2020	2025
GPRA Base				
Solar CSP	0.5	0.5	0.5	0.5
Central PV	0.1	0.2	0.3	0.4
Distributed PV	0.5	0.5	0.5	1.3
Total	1.1	1.2	1.3	2.2
Solar Individual Program Goal Case				
Solar CSP	0.5	0.5	0.5	3.2
Central PV	0.1	0.2	0.3	0.4
Distributed PV	1.4	5.6	30.4	65.2
Total	2.0	6.3	31.2	68.9
Incremental Capacity				
Solar CSP	0.0	0.0	0.0	2.7
Central PV	0.0	0.0	0.0	0.0
Distributed PV	0.8	5.0	29.8	63.9
Total	0.8	5.0	29.8	66.6
Incremental Generation (BkWh)				
Solar CSP	0	0	0.0	18
Central PV	0	0	0.0	0.0
Distributed PV	2	10	60	129
Total	2	10	60	147

Concentrated Solar Power: The improved concentrated solar power (CSP) technology was represented by declining capital costs over time and higher capacity factors. The capital costs goals are higher than those used in the Baseline but represent systems with significantly more storage and, therefore, higher electrical output. A set of capacity factors by time periods within a year were computed by analysts to optimize the timing of solar output for each region within the bounds of the storage potential. The capacity factors and capital costs vary by region, due to differences in solar insolation and resulting storage costs.

Primary energy, oil, and carbon emissions savings result from PV and CSP generation. These savings depend on which types of generating plants were built and operated in the Baseline Case. Over time, the mix of fuels and efficiencies of power generation vary; and, therefore, the energy savings will as well. Energy-expenditure savings are measured as the reduction in consumer expenditures for electricity and other fuels. Lower-cost renewable generation options reduce the price of electricity directly and reduce the pressure on natural gas supply, both of which benefit end-use consumers. Overall benefits of the Solar Energy Technologies Program are shown in **Table 2.10**.

Table 2.10. FY07 Annual Benefits Estimates for Solar Energy Technologies Program (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	ns	0.06	0.35	1.07
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	1.1	2.3	8.1	7.9
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	ns	1	8	29
Security				
Oil Savings (million barrels per day)	ns	ns	0.03	ns
Natural Gas Savings (quadrillion Btu/yr)	ns	0.05	0.09	Ns
Avoided Additions to Central Conventional Power (gigawatts)	ns	3	20	54
Other Program Metrics				
Program-Specific Incremental Generation (gigawatt-hours/yr)	2	10	60	147
Program-Specific Electric Capacity Additions (cumulative gigawatts)	1	5	30	67

More details about the Solar Energy Technologies Program's benefits analysis can be found in **Appendix D**.[16]

Vehicle Technologies Program

The Vehicle Technologies Program consists of research on light-duty vehicle hybrid and diesel technologies, heavy-vehicle engine/drivetrain and parasitic loss-reduction technologies, and lightweight materials for engines and vehicles. The program includes research in advanced petroleum and renewable fuels, the benefits of which are not modeled. In addition, Clean Cities, a deployment program to stimulate greater use of alternative fuels and efficient vehicles, is included within the Vehicle Technologies Program.

Light-duty vehicle hybrid and diesel technologies: This research aims to improve engine technologies in light-duty vehicles, which include passenger cars and light-duty trucks. NEMS-GPRA07 is used to compute benefits estimates for these activities through a process that estimates the penetration (sales) of the various technologies in the market for light-duty vehicles over time. The amount that each technology penetrates into the market determines the stock of these vehicles and the vehicle miles traveled (VMT) associated with each technology.

In the NEMS-GPRA07 integrating model, the light-duty vehicle (LDV) market consists of six car classes—mini-compact, subcompact, compact, midsize, large, two-seater—and six light-duty truck classes—small and large pickup, small and large van, small and large sport utility vehicle (SUV)—in nine Census divisions. For each vehicle type and class and for each region, a number of LDV technologies compete against each other in the market for vehicle sales. These include conventional gasoline, advanced combustion diesel, gasoline hybrids, diesel hybrids, gasoline

[16] Details about the relevant NEMS modules are available at: http://tonto.eia.doe.gov/FTPROOT/modeldoc/m067(2005).pdf (Residential Sector Demand Module), http://tonto.eia.doe.gov/FTPROOT/modeldoc/m066(2005).pdf (Commercial Sector Demand Module), http://tonto.eia.doe.gov/FTPROOT/modeldoc/m068(2004).pdf (Electricity Market Module), and http://tonto.eia.doe.gov/FTPROOT/modeldoc/m069(2005).pdf (Renewable Fuels Module).

fuel cell, hydrogen fuel cell, electric, natural gas, and alcohol. The plug-in HEV (PHEV) activity was added in FY06, but the capability to model the market acceptance of this new vehicle (which uses both electricity and a liquid fuel) has not yet been developed.

Each vehicle technology is represented by a number of characteristics that can change over the forecast time horizon and that influence the technology's acceptance in the marketplace and its sales. These characteristics include the vehicle cost, the fuel cost per mile (a combination of the fuel price and the vehicle efficiency), the vehicle range, the operating and maintenance cost, the acceleration, the luggage space, the fuel availability, and the make and model availability. The NEMS-GPRA07 model also includes "calibration" coefficients to calibrate the model to historical sales data. The associated characteristics for all the alternative technologies are specified as relative to those for the conventional gasoline vehicle.

The model estimates the sales-penetration share of each technology in all of the vehicles, classes, and regions in each year of the forecast. The various characteristics of the technologies determine the technology's value to consumers and its acceptance in the marketplace, but each characteristic has a differing degree of influence. The vehicle cost is generally the most influential of the characteristics, certainly having a much stronger influence than luggage space, for example. The values of all the characteristics are combined together to create an overall value. The technologies are competed against each other, based on the overall values, using a nested logit formulation. In a logit formulation, the relative size of the overall value for each technology determines the relative penetration share for that technology. Technologies that have higher values are given greater sales shares, resulting in a distribution of consumer preferences rather than the technology with the highest value receiving 100% of the market.

In the FY 2007 benefits analysis, the Baseline Case for transportation programs includes some additional penetration of hybrids above the level in the *AEO2005* Reference Case—sales of hybrids are roughly 11% by 2025, compared to only 6% in the *AEO2005*. This reflects the program's view that the *AEO2005* hybrid penetration is too low, due to the roughly constant hybrid vehicle efficiencies and costs over time. For the Baseline Case, the hybrid cost differentials relative to conventional gasoline vehicles were reduced so that they were approximately halfway between the *AEO2005* Reference Case and the Individual Program Goal Case. The model calibration coefficient was also phased out over 20 years to represent a gradual increase in consumer acceptance of hybrids. The effect of the higher hybrid sales in the Baseline is to reduce the incremental benefits credited to the Vehicle Technologies Program.

The Individual Program Goal Case uses the program technology characteristics, along with a variety of other assumptions relating to behavioral responses, in the underlying logit formulation of the NEMS-GPRA07 model. These include modeling an increase in the consumer acceptance of HEVs relative to gasoline internal-combustion engines[17] more rapidly than in the Baseline, and reworking the manner in which the make and model availability coefficients are used.

Lightweight materials for engines and vehicles: The lightweight materials developed under this R&D activity are used in both light and heavy vehicles and are represented in the NEMS-

[17] Modelers, based on the expert judgment of the benefits analysis team, decrease the "calibration coefficients" over time to zero - faster in the Individual Program Goal Case than in the Base Case.

GPRA07 model. For light-duty vehicles, the effect of these materials for hybrids and advanced diesel is included in the projection of vehicle attributes described above, and is not modeled separately. However, for light-duty conventional vehicles, the effect of these materials is modeled using the Manufacturers' Technology Choice (MTC) submodule within NEMS-GPRA07, where an economic decision is made based on the costs and efficiency of the technology. The costs and efficiencies are provided as attributes for an advanced conventional vehicle and transformed for use in existing lightweight technology slots in the MTC. For heavy vehicles, the effect of these materials is included in the projections of penetrations and efficiencies.

Clean Cities: This deployment subprogram is represented through an increase in alternative-fuel vehicles and an increase in dedicated ethanol (E85) vehicles and fuel use. For the increase in alternative-fuel vehicles, analysts used off-line analysis to determine the cumulative number of expected vehicles participating in Clean Cities. These were converted to annual vehicle sales and used as inputs into NEMS-GPRA07. The largest share of vehicles are compressed natural gas, ethanol, and liquefied petroleum gas—electric and methanol vehicle shares are small. For the portion of the program that encourages greater ethanol use, analysts determined the change in the fraction of vehicles using E85 over time and an increasing fraction of E85 use per vehicle. These were converted to overall fractions of E85 use and were then used as inputs to NEMS-GPRA07.

Heavy-vehicle engine/drivetrain and parasitic loss reduction technologies: Heavy vehicles are those that have a gross weight (the weight when fully loaded) of 10,000 pounds or more. This program researches multiple technologies including engines/drivetrains, parasitics/accessories, aerodynamics, and hybrids. The benefits of this R&D activity are derived from penetration rates estimated by the Heavy Truck Energy Balance and TRUCK 2.0 models (developed for the Vehicle Technologies Program), using efficiency and technology cost assumptions. The penetration rates and efficiencies are then used in the NEMS-GPRA07 freight model to increase the efficiency of new vehicles. NEMS-GPRA07 performs the stock accounting for the fleet and determines the overall change in consumption.

Using the integrated NEMS-GPRA07 model, the overall sales share for gasoline light-duty vehicles in 2025 falls from 77% in the Baseline Case to 37% in the Individual Program Goal Case (**Figure 2.2**). This decrease in share is due to the penetration of the alternative technologies. The overall share in 2025 for advanced combustion diesel increases from 5% to 18%; for gasoline hybrids, from 10% to 24%; and, for diesel hybrids, from 1% to 16%.

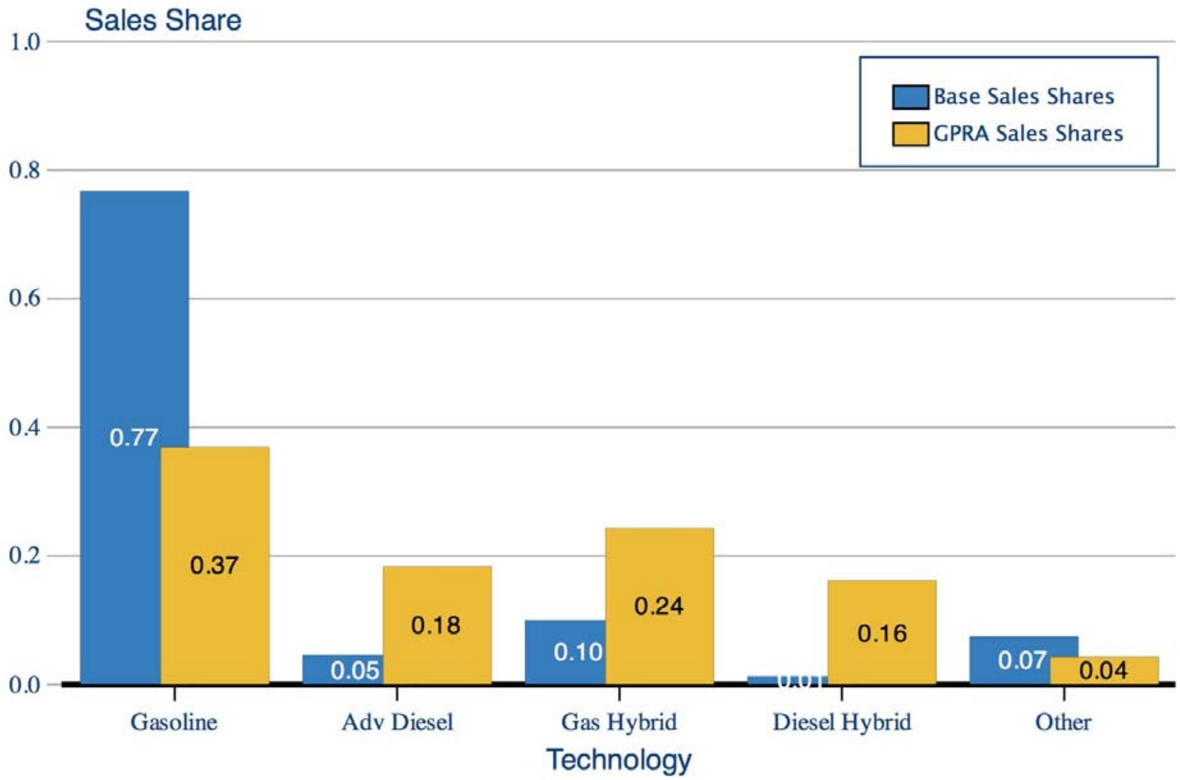


Figure 2.2 Vehicle Technology Sales Share in 2025

These larger vehicle sales shares for advanced technology vehicles in 2025, however, translate into much smaller shares of overall vehicle stocks and overall shares of vehicle miles traveled (VMT) for each technology. The stock shares depend on the share of sales over time, which only gradually increases for the alternative-technology vehicles, and the rate of vehicle replacement and growth. The total VMT for gasoline vehicles falls from 3,311 billion miles in 2025 to 2,563 (just more than 60 percent of the VMT) between the two cases (**Figure 2.3**). The total VMT for advanced-combustion diesel increases from 165 to 378 billion miles (9%); for diesel hybrids, from 25 to 291 billion miles (almost 7%); and, for gasoline hybrids, from 266 to 769 billion miles (18%).

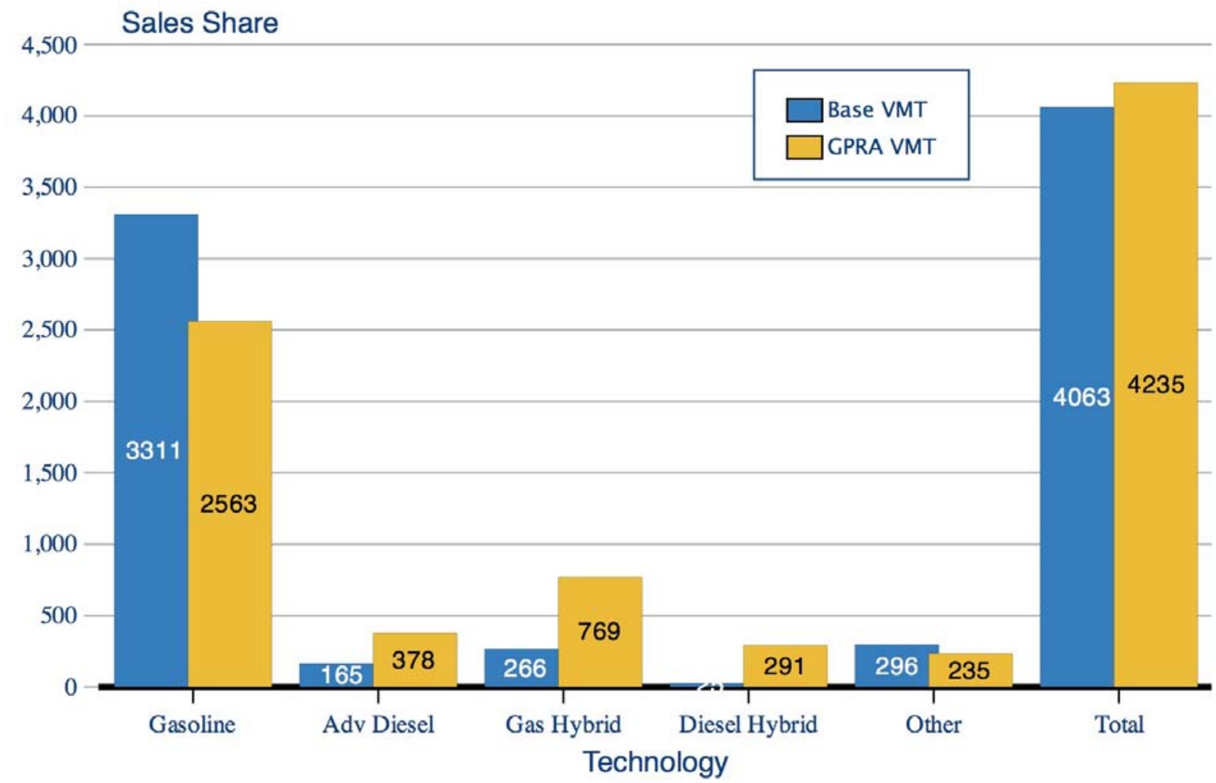


Figure 2.3 Vehicle Miles Traveled in 2025

The miles per gallon (MPG) for advanced-combustion diesel and for hybrid vehicles is much greater than the MPG for conventional gasoline vehicles. In addition, the conventional gasoline vehicles are more efficient, due to adoption of lower-cost lightweight materials. As a consequence of the advanced-technology vehicles substitution for the conventional gasoline vehicles and improved conventional vehicles, there is a considerable amount of fuel savings.

In these integrated NEMS-GPRA07 model runs, the savings are typically somewhat less than what they would be if they were estimated in a transportation-only model, because of feedback effects that come through the integration with other sectors. The primary feedback effect occurs through lower fuel prices. In this case, reduced gasoline demand causes lower gasoline prices, which leads to an increase in travel and less-efficient vehicle purchases than would otherwise have occurred absent the price change. The rebound of gasoline consumption reduces the program savings. At the same time, energy-expenditure savings are greater. The small decreases in price apply to the total amount of fuel consumed and contribute significant additional expenditure savings. In addition, the "rebound" effect is also influenced by the fact that vehicles are more efficient, thereby reducing the cost to drive, causing more miles to be driven. The total effect is that light-duty VMT in 2025 is roughly 4% higher in the Individual Program Goal Case than in the Baseline. **Table 2.11** presents the total program benefits, including those of heavy trucks and Clean Cities.

Table 2.11. FY07 Benefits Estimates for Vehicle Technologies Program (NEMS-GPRA07)[18]

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	0.04	0.38	1.15	2.32
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	ns	4.4	26.2	49.3
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	1	7	20	41
Security				
Oil Savings (million barrels per day)	0.02	0.18	0.52	1.07
Natural Gas Savings (quadrillion Btu/yr)	ns	ns	0.18	0.15
Avoided Additions to Central Conventional Power (cumulative gigawatts)	ns	ns	ns	ns

More details about the Vehicle Technologies Program's benefits analysis can be found in **Appendix F**.[19]

Weatherization and Intergovernmental Program

The Weatherization and Intergovernmental Program (WIP) encompasses several market-enhancement activities, rather than R&D. The major components include: International, Native American Renewable Initiative (also referred to as Tribal Energy), the Renewable Energy Production Incentive (REPI), Weatherization (Assistance), and State Energy Program Grants. The FY 2007 benefits estimate methodologies vary by activity. The International activities are currently outside the scope of the integrated modeling framework.

Weatherization and State Energy Program Grants are implementation programs that lead to greater adoption of energy efficiency. The projected energy savings are based on the program's evaluations of past experience for these programs. Weatherization is aimed primarily at achieving heating and cooling energy reductions in homes of low-income households. T o determine the annual energy savings, the number of homes projected to be weatherized is combined with the expected savings per household. The State Energy Program provides financial assistance to States and encompasses a number of types of activities including codes and standards, energy audits, retrofits, labeling, workshops and training, incentives, loans and grants, and technical assistance. Energy savings are estimated for each of these activities based on evaluations of prior-year efforts. The Weatherization and SEP energy savings are represented in NEMS-GPRA07 by reducing energy consumption in the residential and commercial sectors, based on the program goals.

The Native American renewable initiative offers assistance for renewable energy feasibility studies and shares the cost of renewable energy projects on tribal lands. The goal is the electrification of currently nonelectrified occupied housing and the offsetting of more

[18] Note that in the Vehicle Technologies Individual Program Goal Case, the advanced ethanol production technologies available in the Biomass Program's Case are unavailable, despite the market synergies of the two suites of technologies. In the EERE portfolio case, both suites are modeled.
[19] Details about the relevant NEMS modules are available at: http://tonto.eia.doe.gov/FTPROOT/modeldoc/m070(2005).pdf (Transportation Sector Module).

expensively provided electricity on tribal lands. Analysts made projections of central station wind and biomass capacity that would be stimulated by the program, as well as home-installed PV systems, based on the program's goals. The wind and biomass capacities were added as "planned additions"[20] within the NEMS-GPRA electricity sector. The additional PV capacity is counted in the benefits for added program capacity, but is not included in the modeling as displacing conventional generation and fuel consumption, because the systems provide electrifications to those who would not have it otherwise.

REPI provides payments to publicly owned utilities, such as municipal utilities or rural electric cooperatives, for electricity generation from renewable energy sources. These payments are the public power equivalent of the production tax credit for investor-owned renewable generators. Analysts projected the amount of new renewable generation that is likely to be stimulated by future REPI payments based on the requested budget levels and historical patterns of payments. Almost all the new generation is expected to be wind, based on the eligibility criteria and past experience. Some of the wind capacity added as planned builds to represent WIP displaces economic wind builds in NEMS-GPRA07, so the incremental is less than that calculated off-line. Overall benefits for WIP are shown in **Table 2.12**.

Table 2.12. FY07 Annual Benefits Estimates for Weatherization and Intergovernmental Program (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	0.06	0.13	0.15	0.20
Economic				
Energy-Expenditure Savings (billion 2003 dollars/yr)	ns	1.2	2.9	2.3
Environmental				
Carbon Savings (million metric tons carbon equivalent/yr)	1	3	3	4
Security				
Oil Savings (million barrels per day)	ns	0.01	0.04	0.01
Natural Gas Savings (quadrillion Btu/yr)	0.02	0.07	0.07	0.11
Avoided Additions to Central Conventional Power (gigawatts)	ns	2	1	2
Other Program Metrics				
Program-Specific Incremental Generation (gigawatt-hours/yr)	1	11	7	17
Program-Specific Electric Capacity Additions (cumulative gigawatts)	1	4	3	5

More details on the Weatherization and Intergovernmental Program's benefits analysis can be found in **Appendix J**.[21]

[20] In NEMS, there are two ways that generation capacity is added to the energy system. "Builds" are capacity additions that the model endogenously calculates based on energy supply and demand. "Planned additions" are specific plants that are included in the model's capacity expansion plan based on modeler knowledge. These can represent capacity under construction at the time the forecast is made, capacity that is anticipated to meet local requirements (such as State renewable portfolio standards or State incentives), or capacity that may be built for site- or institution-specific reasons that are not reflected in the model's endogenous decision framework. The planned additions will displace capacity that the model would have otherwise built. Because there are supply curves for biomass and wind resources, the planned builds may, in part, offset endogenous builds of these resources.

[21] More details on the relevant NEMS module are available at: http://tonto.eia.doe.gov/FTPROOT/modeldoc/m067(2005).pdf (Residential Sector Demand Module), http://tonto.eia.doe.gov/FTPROOT/modeldoc/m066(2005).pdf (Commercial Sector Demand Module), and http://tonto.eia.doe.gov/FTPROOT/modeldoc/m068(2004).pdf (Electricity Market Model).

Wind Technologies Program

The wind component of the Wind Technologies Program seeks to reduce the cost—and improve the performance—of wind generation. The FY 2007 benefits are based primarily on projecting the market share for wind technologies, based on their economic characteristics.

Representation of Wind: The NEMS-GPRA07 electricity-sector module performs an economic analysis of alternative technologies in each of 13 regions. Within each region, new capacity is selected based on its relative capital and operating costs, its operating performance (i.e., availability), the regional load requirements, and existing capacity resources. NEMS-GPRA07 characterizes wind by three wind classes, each with its own capital costs and resource cost multipliers. The regional resource cost multipliers act to increase costs as more of a wind class is developed in a region, and development may move to the next most cost-effective wind class. NEMS-GPRA07 assumes that the capacity value of wind diminishes with greater wind capacity in a region. Finally, another constraint on the growth of wind-resource development is how quickly the wind industry can expand before costs increase due to manufacturing bottlenecks. As in the *AEO2005,* the Individual Program Goal Case[22] (see **Table 2.13**) assumes that a cost premium is imposed when new orders in a year are 20% higher than in the highest of the previous 10 years.

The baseline characterizations of wind capital costs and capacity factors were modified to reflect a more consistent view relative to the program goals. The Baseline costs were reduced over time so that, by 2050, the onshore cost remains below the offshore costs by a ratio equivalent to that of that ratio in the Individual Program Goal Case. In addition, the capacity factors were increased for all three wind classes. The effect of these changes is to increase onshore wind capacity in the Baseline relative to the *AEO2005*, which reduces the benefits attributed to the program, but presents a better representation of the impact of the program's R&D.

NEMS-GPRA07 also includes a representation of offshore wind that is not in the *AEO2005* version of the NEMS model. The offshore wind is represented as a distinct technology that competes with all other generation technologies. It is characterized in a manner similar to onshore wind, with three wind classes—but also has a distinction between shallow and deeper water (transitional) sites. The constraints on intermittent generation and rapid growth apply similarly to offshore as to onshore wind development. The offshore wind does not have the regional resource cost multipliers, because there is insufficient data on how they might apply. The Baseline technology characteristics assume that improvements would occur without EERE R&D, but at a slower pace of roughly 10 years later.

Analysts represented the Wind Program R&D activities by reducing the capital and O&M costs and increasing the performance of wind capacity to match the program cost goals.

Table 2.14 provides the estimates of primary energy, oil, and carbon emissions savings stemming from wind and hydropower displacing fossil-fueled generation sources. Analysts measure the energy-expenditure savings as the reduction in consumer expenditures for electricity

[22] In the *AEO2005,* all generation technologies face similar premiums associated with rapid growth.

and other fuels. Lower-cost renewable generation options reduce the price of electricity directly and reduce the pressure on natural gas supply, both of which benefit end-use consumers.

Table 2.13. Wind Capacity (GW)

		2010	2015	2020	2025
AEO Base		8.9	9.3	10.5	11.3
GPRA Baseline					
Onshore	Class 6	4.0	4.8	8.1	8.8
	Class 5	4.4	7.8	15.7	20.7
	Class 4	0.5	0.6	0.7	2.9
	Subtotal	8.9	13.2	24.5	32.3
Offshore	Class 7	0.0	0.0	0.0	0.9
	Class 6	0.0	0.0	0.0	2.9
	Class 4&5	0.0	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.0	3.8
Total	Total	8.9	13.2	24.5	36.2
Wind Individual Program Goal Case					
Onshore	Class 6	4.0	5.5	8.4	8.7
	Class 5	4.4	8.8	21.8	24.1
	Class 4	0.5	4.6	28.8	47.0
	Subtotal	8.9	18.9	59.0	79.8
Offshore	Class 7	0.0	0.0	0.9	3.5
	Class 6	0.0	0.1	17.7	47.4
	Class 4&5	0.0	0.0	0.0	5.2
	Subtotal	0.0	0.1	18.7	56.1
Total	Total	8.9	19.0	77.6	135.8
Incremental Capacity					
Onshore	Class 6	0.0	0.7	0.3	0.0
	Class 5	0.0	1.0	6.1	3.4
	Class 4	0.0	4.0	28.1	44.1
	Subtotal	0.0	5.7	34.5	47.5
Offshore	Class 7	0.0	0.0	0.9	2.6
	Class 6	0.0	0.1	17.7	44.5
	Class 4&5	0.0	0.0	0.0	5.2
	Subtotal	0.0	0.1	18.7	52.2
Total	Total	0.0	5.8	53.1	99.7

Table 2.14. FY07 Benefits Estimates for Wind Technologies Program (NEMS-GPRA07)

Benefits	2010	2015	2020	2025
Energy Displaced				
Primary Nonrenewable Energy Savings (quadrillion Btu/yr)	ns	0.14	1.60	3.10
Economic				
Energy-Expenditure Savings (billion 2003 dollars/year)	ns	1.2	10.5	17.6
Environmental				
Carbon Savings (million metric tons carbon equivalent/year)	ns	3	34	69
Security				
Oil Savings (million barrels per day)	ns	ns	0.11	0.09
Natural Gas Savings (quadrillion Btu/year)	ns	0.10	0.48	0.83
Avoided Additions to Central Conventional Power (gigawatts)	ns	1	14	17
Other Program Metrics				
Program-Specific Incremental Generation (gigawatt-hours/yr)	0	23	225	429
Program-Specific Electric Capacity Additions (cumulative gigawatts)	0	6	53	100

More information about the Wind Program's benefits analysis can be found in **Appendix E**.[23]

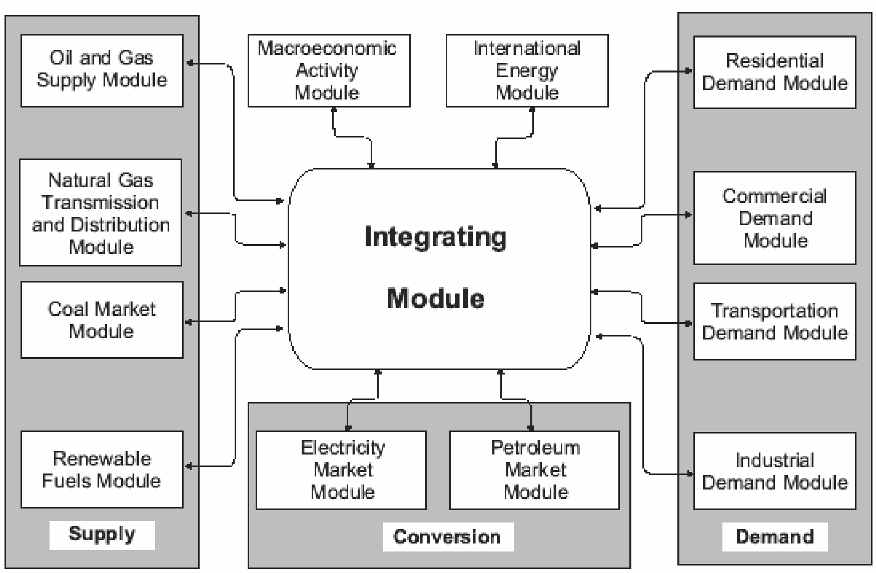
[23] Details about the relevant NEMS modules are available at: http://tonto.eia.doe.gov/FTPROOT/modeldoc/m068(2004).pdf (Electricity Market Module) and http://tonto.eia.doe.gov/FTPROOT/modeldoc/m069(2005).pdf (Renewable Fuels Module).

Box 2.1—EIA's National Energy Modeling System (NEMS)*

The National Energy Modeling System (NEMS) is an energy-economy modeling system of U.S. energy markets for the midterm period through 2025. NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. NEMS was designed and implemented by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE). As described in the GPRA Baseline section, the NEMS-GPRA07 version of the model used for the EERE GPRA analysis includes minor modifications to the standard EIA NEMS.

NEMS is designed as a modular system. Four end-use demand modules represent fuel consumption in the residential, commercial, transportation, and industrial sectors—subject to delivered fuel prices, macroeconomic influences, and technology characteristics. The primary fuel supply and conversion modules compute the levels of domestic production, imports, transportation costs, and fuel prices that are needed to meet domestic and export demands for energy—subject to resource base characteristics, industry infrastructure and technology, and world market conditions. The modules interact to solve for the economic supply and demand balance for each fuel. Because of the modular design, each sector can be represented with the methodology and the level of detail (including regional detail) that is appropriate for that sector.

A key feature of NEMS is the representation of technology and technology improvement over time. Five of the sectors—residential, commercial, transportation, electricity generation, and refining—include extensive treatment of individual technologies and their characteristics, such as the initial capital cost, operating cost, date of availability, efficiency, and other characteristics specific to the sector. Technological progress results in a gradual reduction in cost and is modeled as a function of time in these end-use sectors. In addition, the electricity sector accounts for technological optimism in the capital costs of first-of-a-kind generating technologies and for a decline in cost as experience with the technologies is gained both domestically and internationally. In each of these sectors, equipment choices are made for individual technologies as new equipment is needed to meet growing demand for energy services or to replace retired equipment. In the other sectors—industrial, oil and gas supply, and coal supply—the treatment of technologies is more limited, due to a lack of data on individual technologies. In the industrial sector, only the combined heat and power and motor technologies are explicitly considered and characterized. Cost reductions resulting from technological progress in combined heat and power technologies are represented as a function of time as experience with the technologies grows. Technological progress is not explicitly modeled for the industrial motor technologies. Other technologies in the energy-intensive industries are represented by technology bundles, with technology possibility curves representing efficiency improvement over time. In the oil and gas supply sector, technological progress is represented by econometrically estimated improvements in finding rates, success rates, and costs. Productivity improvements over time represent technological progress in coal production.



* Most of this description is taken from *The National Energy Modeling System: An Overview 2003*, DOE/EIA-0581(2003), March 2003. The document is available at http://tonto.eia.doe.gov/FTPROOT/forecasting/05812003.pdf .