CHAPTER 3 – THE VALUE OF INDIVIDUAL EERE PROGRAMS

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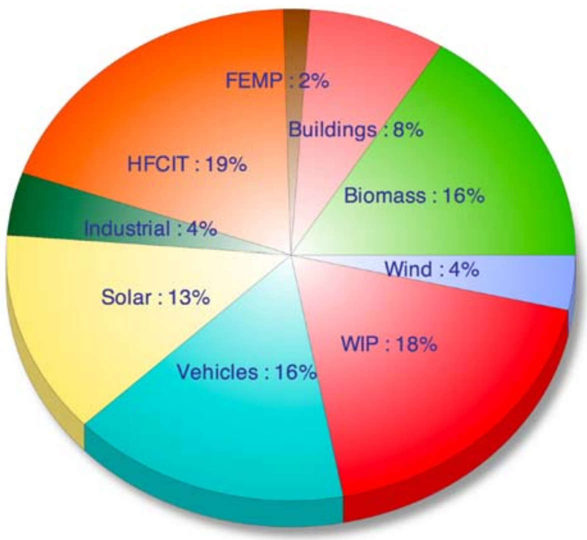
Introduction

The Office of Energy Efficiency and Renewable Energy (EERE) funds nine Research, Development, Demonstration, and Deployment (RD3) programs. **Figure 3.1** displays the EERE program budget requests for FY 2007. The top two largest program budgets are $213 million for the Hydrogen, Fuel Cell, and Infrastructure Technologies (HFCIT) Program, and $205 million for the Weatherization and Intergovernmental Program (WIP). The latter includes $144 million for Low-Income Weatherization Assistance.



Federal Energy Management	$16,791
Wind	$40,069
Industry	$45,998
Buildings	$86,456
Solar	$148,304
Vehicles	$176,138
Biomass	$179,263
Weatherization/Intergovt	$204,904
H_2 Fuel Cell Infrastructure	$213,000

Figure 3.1. FY 2008 Budget Request for EERE Programs

Source: Budget request from *FY 2008 Budget-in-Brief*, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, http://www1.eere.energy.gov/ba/pba/budget_08.html

Overview of Individual Program and Portfolio Benefits

This chapter focuses on the estimated benefits of the individual programs under the "Business-as-Usual" (BAU) scenario, and how they compare with the benefits of EERE's overall portfolio under the BAU scenario. Individual program benefits are not—in sum—equal to the total benefits of the integrated EERE portfolio. That is because individual programs can compete or be synergistic with other programs in the portfolio.[1] The individual program benefits presented here represent how each program's technologies can compete in the U.S. energy market by themselves, without the presence of any other programs in the EERE portfolio and ESE programs.

Still, the individual program benefits presented here serve as a proxy for understanding the relative strengths of each program's activities. To highlight the relative impacts of the programs, this section provides graphs depicting each program's metrics as stacked "slices" on an area chart of a given metric vs. time, so that the upper edge of the stack represents the sum of the individual program metric values (see **Figure 3.2** for illustration). For comparison, a dashed line representing the value of each metric over time for the integrated EERE portfolio is also provided. In most cases, the dashed line does not correspond with the top of the stacked individual program slices, reflecting the fact that—when all of the

[1] The individual program benefits are computed as the difference between the Baseline and the Individual Program Goal Case, which includes only the impacts of the one program.

programs' outcomes are modeled together—there is competition that will lower the portfolio value, or synergy that will raise the portfolio value relative to the sum of the individual programs. In general, the values projected for the portfolio range within +/- 10% of the sum of the individual program values for all of the metrics. The discontinuity shown here between 2030 and 2035 reflects the fact that there are two different models used in the midterm (through 2030) and the long term (2030 to 2050).

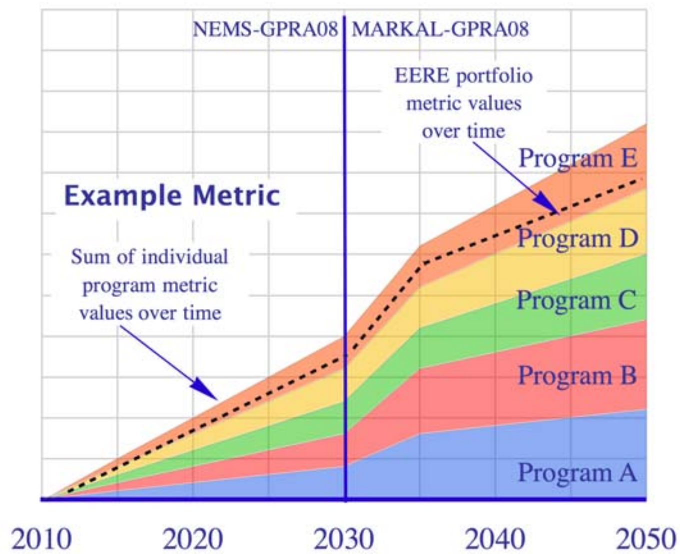


Figure 3.2. Illustration of Individual Program Benefits Charts

Note that the Federal Energy Management Program (FEMP) and the Weatherization and Intergovernmental Program (WIP) values are typically too small to show up on the charts. This is indicative of the problem that the metrics selected for DOE's RD3 programs do not measure the societal values associated with these programs. In the case of WIP, the programs provide energy savings for low-income households and provide opportunities for Native American tribes. FEMP provides opportunities to showcase or prove new energy technologies within the Federal government, and also assures Federal leadership in adopting advanced energy technologies.

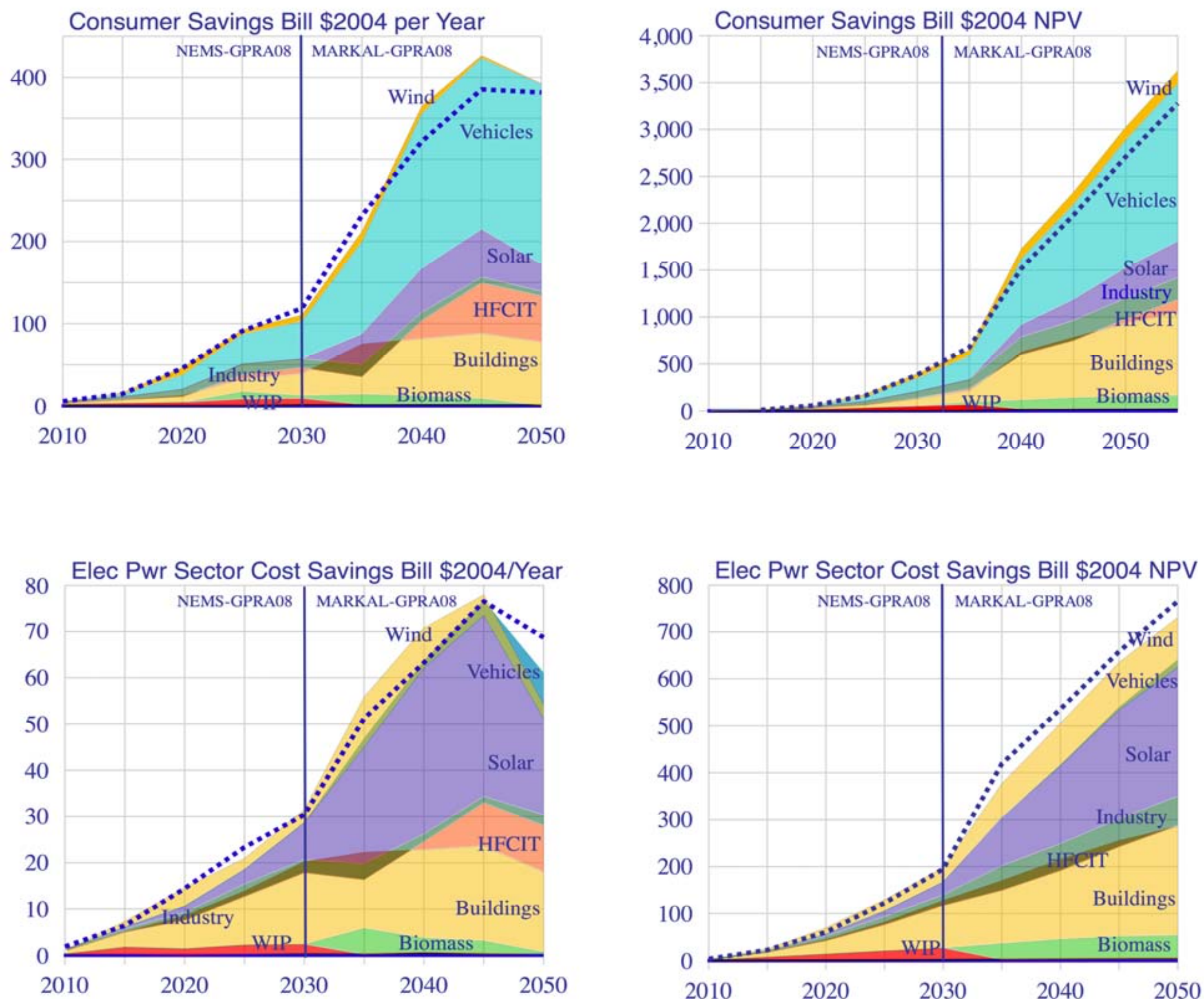
The variety of metrics included in this year's report sheds light on the differing roles that each of the programs potentially have in EERE's portfolio.[2] Some programs, for example, show greater potential impact on consumer savings, while others show greater potential impact on electric power costs and overall energy system savings. For greenhouse gas reductions, different programs show greater or less impact in the midterm vs. the long term. The three programs related to transportation dominate security benefits.[3]

Economic Benefits

Figure 3.3 shows projected consumer and electric power industry savings associated with EERE's portfolio and each of its individual programs. The biggest contributors to consumer savings are the FreedomCAR and Vehicle Technologies, and Building Technologies programs—most likely attributable to less spending on energy because of the availability of more energy-efficient vehicles and buildings.

[2] For a more detailed explanation of the metrics, see Chapter 1.
[3] Note that these comparisons do not include the effect of differences in the relative risk associated with meeting the programs' goals.

Vehicle Technologies and Building Technologies represent 64% and 71% of the sum of individual programs' cumulative consumer savings in 2030 and 2050, respectively.



Dashed line represents total integrated EERE portfolio. Results for midterm (through 2030) from NEMS-GPRA08 model. Results for long term (2030 through 2050) from MARKAL-GPRA08 model

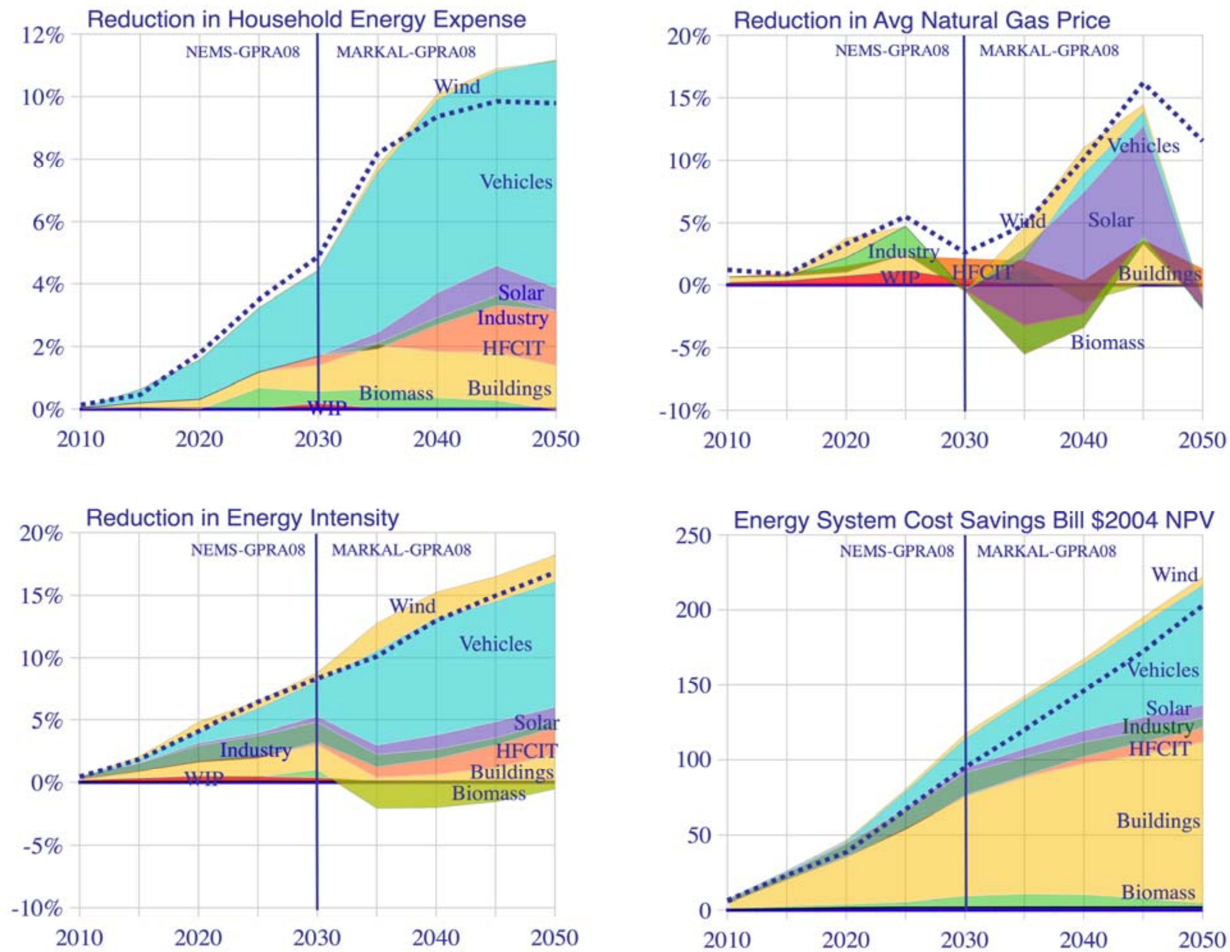
Figure 3.3. Consumer and Electric Power-Sector Savings for EERE Portfolio and Individual Programs[4]

By 2050, the Solar Energy Technologies, and Hydrogen, Fuel Cell, and Infrastructure Technologies programs contribute significantly to annual consumer savings. For the electric power sector, on the other hand, Solar Technologies and Building Technologies show the greatest individual potential for savings. Together, they represent more than 70% of the sum of individual programs' cumulative electric power sector savings in 2050. Wind Technologies has much more impact on electric power savings than it does on overall consumer savings.

The remaining economic metrics are shown in **Figure 3.4**. The Vehicles Technologies Program shows the greatest potential for reducing the relative amount of household income spent on energy—roughly two-thirds of the sum of individual program effects. It also has the greatest potential for reducing energy

[4] Benefits for Weatherization and Intergovernmental Programs (WIP) are not estimated beyond 2030.

intensity of the economy—60% of the sum of the individual program reductions in 2050. Biomass actually increases energy intensity,[5] while the Solar, Wind, HFCIT, and Buildings programs almost equally contribute to the remaining 40% of reduced energy intensity in 2050. In the near to midterm, the Industrial Technologies Program shows its greatest potential impact on energy intensity—especially in the early years.



Dashed line represents total integrated EERE portfolio. Results for midterm (through 2030) from NEMS-GPRA08 model. Results for long term (2030 through 2050) from MARKAL-GPRA08 model

Figure 3.4. Household Spending, Natural Gas Prices, Energy Intensity, and Energy System Cost Savings for EERE Portfolio and Individual Programs[6]

Energy system savings—an approximate measure of the impact of EERE's RD3 programs on the consumer and producer surplus—appear to be dominated by Vehicles Technologies and Buildings Technologies in the individual program results. The combined potential savings of these two programs is more than 80% of the sum of the individual program energy system savings in 2050. The Industrial Technologies and Biomass programs have their greatest relative potential impact in the midterm, with their combined potential savings representing almost 20% of the total individual program savings.

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[5] The overall efficiency of converting the primary energy in biomass into fuels is lower than that of converting petroleum to fuels. Use of biofuels therefore increases energy intensity of the economy even though it decreases oil intensity of the economy.
[6] Benefits for Weatherization and Intergovernmental Programs (WIP) are not estimated beyond 2030.

Effects on average natural gas prices are much more mixed, with higher demand from Biomass and HFCIT programs resulting in potential increases in natural gas prices in the 2030 to 2040 time frame. From 2020 to 2030, the Industrial Technologies Program shows the greatest potential for reducing natural gas prices; while, in the long term, the Solar Program leads to the greatest price reduction.

Environmental Benefits

Figure 3.5 shows the avoided emissions of greenhouse gases associated with energy production and use for the individual program cases and the EERE portfolio case. In 2030, the Buildings Technologies, Vehicles Technologies, Industry, Wind, and Solar programs all show roughly the same potential for avoiding greenhouse gas emissions cumulatively by 2030, with these five programs totaling about 90% of the 4.5 billion metric tons of greenhouse gas savings achieved. By 2050, Vehicles Technologies account for 30% of the sum of the cumulative savings of the individual programs, followed by the Wind and Buildings programs, which together account for another 30% of the sum of the cumulative savings of the individual programs.

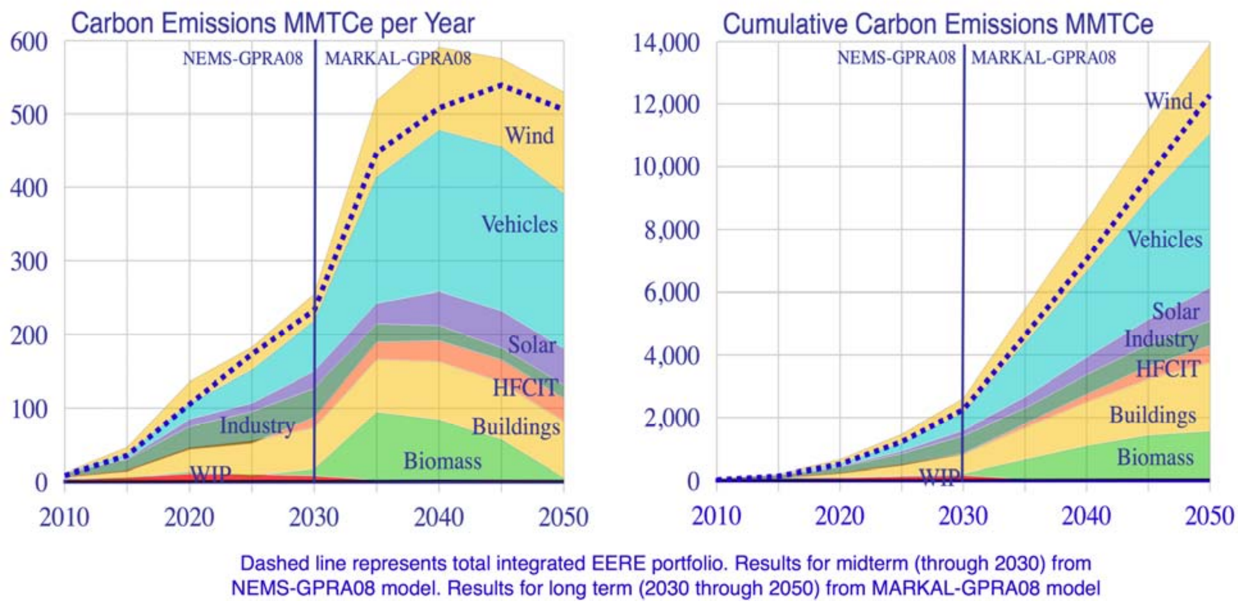


Figure 3.5. Avoided Greenhouse Gas Emissions for the EERE Portfolio and Individual Program Cases

Figure 3.6 shows the avoided criteria pollutant costs for the individual programs and the EERE portfolio cases under the BAU scenario through 2030. Because this cost is based on pollutant emissions trading values, only those programs affecting electricity production and use show value. Of these, only the Buildings Technologies and Wind programs show any measurable reductions by 2030.[7]

Security Benefits

Figure 3.7 shows security benefits for the EERE portfolio and individual program cases under the BAU scenario. The transportation-related programs of Vehicles, HFCIT, and Biomass dominate these benefits. Together, the Vehicles and HFCIT programs represent more than 80% of the sum of the individual program's cumulative oil savings in 2050.

[7] Pollution control cost savings are not estimated beyond 2030 because they are not modeled in MARKAL-GPRA08.

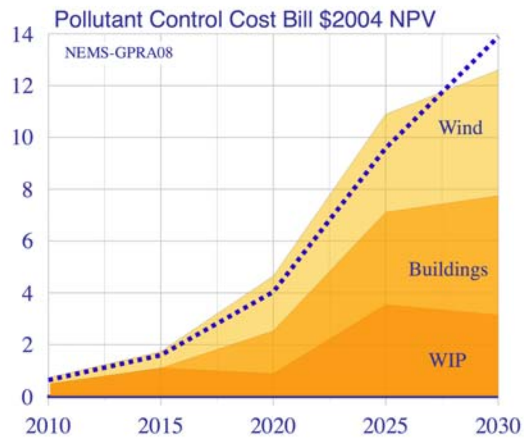
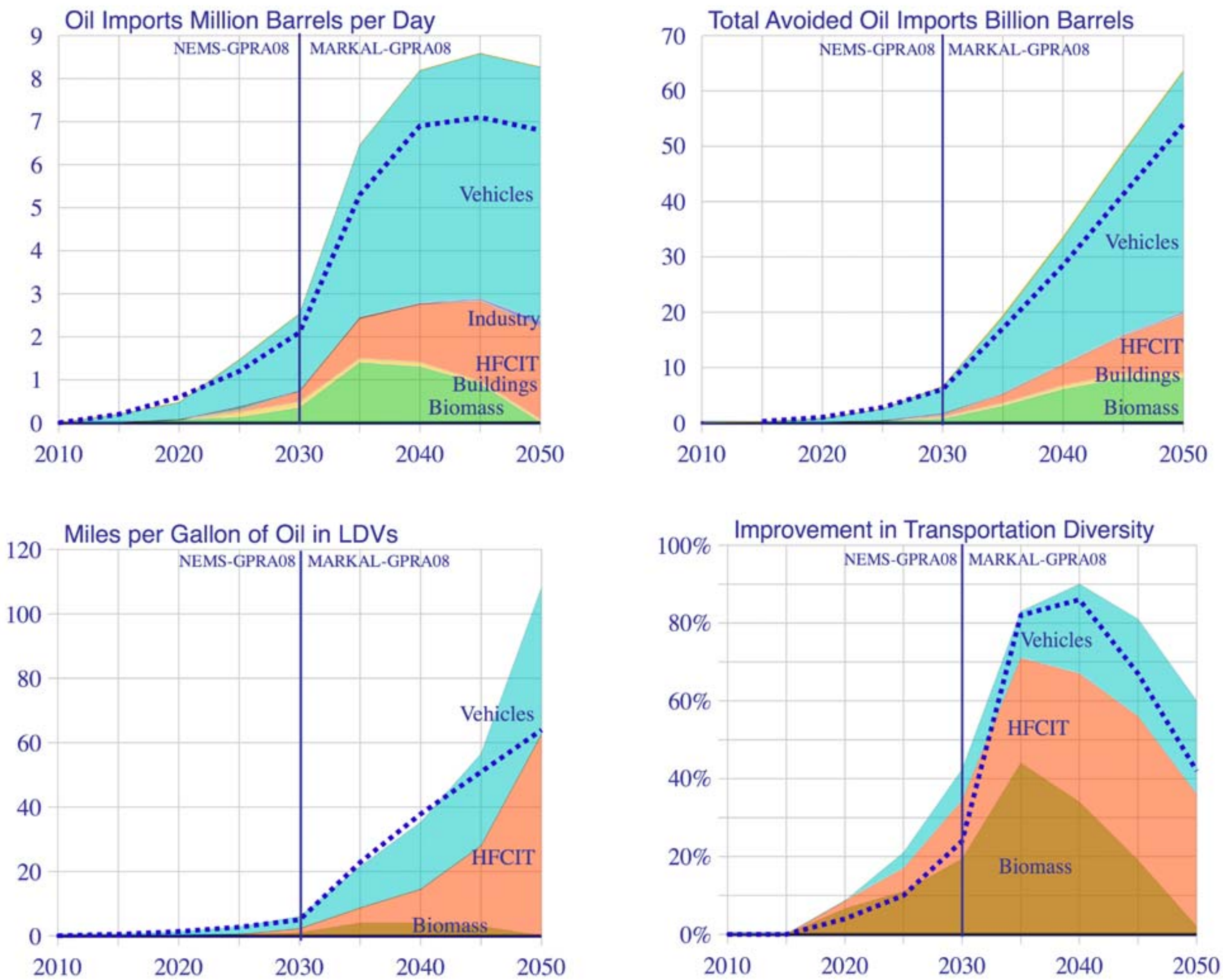


Figure 3.6. Avoided Criteria Pollutant Control Costs for the EERE Portfolio and Individual Program Cases



Dashed line represents total integrated EERE portfolio. Results for midterm (through 2030) from NEMS-GPRA08 model. Results for long term (2030 through 2050) from MARKAL-GPRA08 model

Figure 3.7. Security Benefits for the EERE Portfolio and Individual Program Cases

Biomass Program

On February 20, 2006, in his State of the Union Speech, President Bush announced the Advanced Energy Initiative (AEI). The Biofuels Initiative, a key component of the AEI, is designed "to foster the breakthrough technologies needed to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012, enabling greater use of this alternative fuel to help reduce future U.S. oil consumption." DOE's Biomass Program is working to meet these goals by displacing a significant volume of gasoline.

The Biomass Program is currently revising its multiyear plan to reflect the budget, activities, and outputs required to achieve its revised goals. Key outputs of the Biomass Program are summarized in **Table 3.1**.

Table 3.1. Key Biomass Program Outputs and Milestones

Outputs	Key Milestones
Enable first corn biorefinery with corn fiber and residual starch	• Conclude commercial demo with industry partner to increase ethanol output by at least 4% for each biorefinery by 2009
Enable first pilot-scale project with corn stover	• Cost and performance evaluated at pilot scale against target selling price of $1.07 per gallon of ethanol with a $35/ton feedstock cost or $1.22 per gallon with a $45/ton feedstock cost by 2012
Enable first demonstration-scale project with corn stover	• Deliver technology for stover collection and storage to demonstration scale project at costs of $35 to $45 per dry ton by 2013
Enable switchgrass commercialization	• Increase switchgrass yield per acre by 10% at test sites by 2015 (from current regional levels) • Increase switchgrass yield per acre by an additional 5% at test sites by 2019 • Deliver technology for switchgrass collection and storage to demo-scale ethanol conversion project for $45 per ton by 2019
Enable first pilot-scale project with switchgrass and residues	• Cost and performance evaluated at pilot scale against target yield of 90 gallons per ton by 2017
Enable first demonstration-scale project with switchgrass or forest residues	• Cost and performance evaluated at demonstration-scale against target yield of 90 gallons per ton of feedstock by 2020
Enable next-generation cellulosic biorefineries for ethanol production	• Deliver faster growing switchgrass and more competitive technologies for biomass production, collection, and storage to demonstration facilities • Industry partners construct, operate, and evaluate subsequent demonstration-scale projects

Translating Biomass Program Goals into Energy Model Parameters

The outputs of the Biomass Program are translated into input parameters for a Biomass Program Case under the BAU scenario. In addition, some adjustments are made to the *AEO2006*[8] reference case to best reflect the base case for the future of biomass technologies in the absence of continued Biomass Program RD3 activities. **Figure 3.8** highlights some (but not all) of the key parameters adjusted in both the base case and program case. The projected cost reductions for corn and cellulosic ethanol in the program case are anchored in the outputs listed in **Table 3.1.** The base case for biofuels technology is significantly different from the *AEO2006* reference case. The Biomass Program believes that projected costs for corn and cellulose ethanol technology are lower than *AEO2006*'s assumptions. Furthermore, while the *AEO2006* reference case assumes that technology costs for corn and ethanol will not change over time, the program posits continued cost reductions for corn ethanol, identical to those associated with Biomass Program case projections, but delayed by seven years without the program's RD3 activities. Similarly, the program assumes eventual technology development for cellulose technology in the baseline case that lags

[8] *Annual Energy Outlook 2006: With Projections to 2030*. Energy Information Administration, U.S. Department of Energy, Washington, D.C. (February 2006). DOE/EIA-0383(2006).

15 years behind the program's targets. More details on how inputs to the energy models were developed for the Biomass Program are available in the appendices of this report.

Figure 3.8. Selected Biomass Technology Input Parameters for Integrated Benefits Modeling

Individual Program Case Results for Biomass

Figure 3.9 shows projected ethanol market penetration for the base case and program case under the BAU scenario. The yellow- and green-area plots represent total corn and cellulosic ethanol production, respectively. The blue bars show the difference in ethanol production between the base case and the program case.

Midterm NEMS-GPRA08 results show that success in Biomass Program RD3 leads to 23 billion gallons of ethanol by 2030 with 14 billion gallons supplied through the cellulosic process, compared to 12 billion gallons of almost all corn-based ethanol in the base case. Corn ethanol production declines slightly after 2020, due to the increasing competitiveness of cellulosic-based ethanol, saturation of the gasoline blending market, and still somewhat limited use of E85 in vehicles.

Long-term MARKAL-GPRA08 results show more than 60 billion gallons per year of ethanol production for the program case by 2050, with corn ethanol production topping out at 12 billion gallons per year. The jump in ethanol between 2030 and 2035 reflects differences between the two modeling systems rather than a real jump in ethanol production. The NEMS-GPRA08 model limits ethanol demand in the midterm much more than MARKAL-GPRA08. This appears to be related to constraints in NEMS-GPRA08 on market penetration of E85 fuel and vehicles.

The impact of the program on ethanol production peaks in 2035, and declines dramatically by 2050—due to the assumption that the industry in the base case catches up with progress in cellulosic ethanol technology under the program case in 15 years.

Table 3.2 summarizes the benefits for the individual Biomass Program case under the BAU scenario. The Biomass Program benefits reflect the differences between the Individual Program Goal Case compared with the Baseline Case.

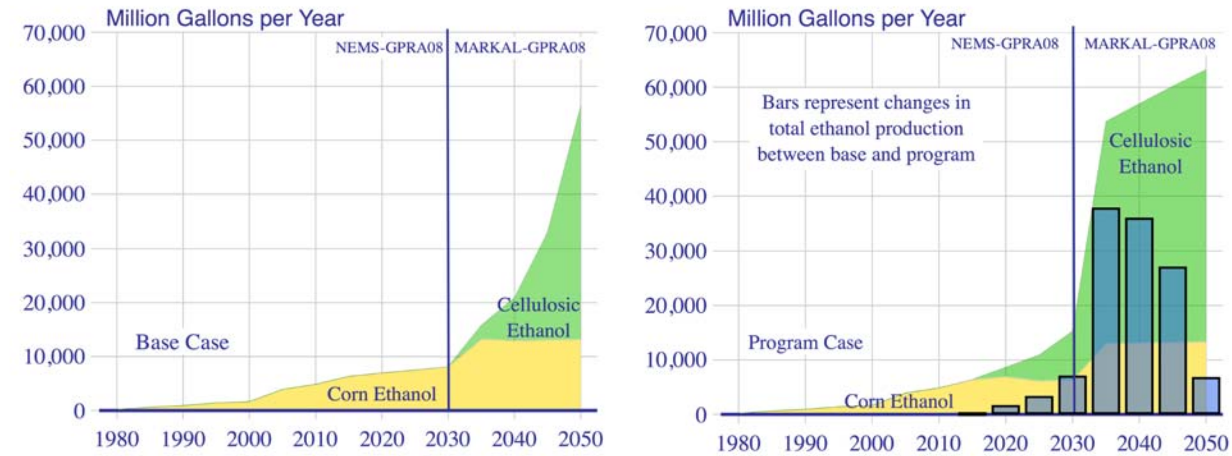


Figure 3.9. Projected Ethanol Growth for the Biomass Program under the BAU Scenario

Table 3.2. FY08 Annual Benefits Estimates for the Biomass Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	ns	ns	ns	ns	ns	1%	-1%	0%	0%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	8	7	5	2
Consumer Savings, Annual (bil $2004)	ns	ns	ns	9	3	14	13	15	0
Consumer Savings, NPV (bil $2004) 2/	ns	ns	ns	7	25	67	94	119	128
Electric Power Industry Savings, Annual (bil $2004) 3/	ns	ns	ns	ns	ns	6	3	3	0
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	ns	ns	ns	ns	ns	35	43	48	51
Reduction in Fraction of Household Income Spent on Energy	0.0%	0.0%	0%	1%	0%	1%	0%	0%	0%
Reduced Energy Intensity of Economy (Percent)	0%	0%	0%	0%	1%	-2%	-2%	-2%	-1%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	ns	ns	3	-2	9	93	81	55	3
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	ns	ns	20	26	46	624	1,052	1,380	1,502
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	ns	ns	ns	ns	ns	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	0.1	0.1	0.3	1.4	1.3	0.9	0.0
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	0	1	3	6	8	8
Security Fuel Economy Improvement (MPG)	ns	ns	0	0	1	4	4	3	0
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	7%	11%	19%	44%	34%	19%	2%
Reduced Oil Intensity (Percent)	ns	ns	0%	1%	1.5%	7%	6%	4%	0%

Table notes:
1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

The most significant benefits in the midterm NEMS-GPRA08 results (though 2030) are a reduction in oil imports and an increase in fuel diversity in the transportation sector. Increased use of ethanol (blended with gasoline and as E85) reduces oil imports by 0.3 million barrels per day (or 2%) in 2030. The security MPG increases by 1.0 MPG relative to the base case or 4%, and the diversity index for transportation increases by 19%. Consumer savings, resulting from lower blended gasoline and ethanol prices, are relatively modest (0.4% of overall annual household energy costs and a total of $4 billion on a net present value basis through 2030). Carbon emission reductions are small with corn ethanol displacement of gasoline, but increase once cellulosic ethanol is introduced.

In the long-term MARKAL-GPRA08 results, avoided oil imports peak in 2035 at 1.4 million barrels per day, falling to zero by 2050 when the baseline case presumably catches up with the program case. At their peak in 2035, the security MPG is improved by 4 MPG and the diversity index for transportation fuel is improved by 44%, relative to the base case. Consumer savings remain modest, peaking at $14 billion per year in 2035. Carbon emission reductions are substantial in the long term, peaking at 93 million metric tons of carbon equivalent per year in 2035, due partly to the greater incremental ethanol demand—most of which is met with less carbon-intensive cellulosic ethanol. Furthermore, cellulosic ethanol's associated cogeneration component displaces coal-fired generation, which further increases carbon savings.

Building Technologies Program

The mission of the Building Technologies Program (BT) is to develop technologies, techniques, and tools for making residential and commercial buildings more energy efficient, productive, and affordable. The program has defined its strategic goal more specifically as:

> To create technologies and design approaches that enable net-zero energy buildings at low incremental cost by 2025. A net-zero energy building is a residential or commercial building with greatly reduced needs for energy through efficiency gains (60% to 70% less than conventional practice), with the balance of energy needs supplied by renewable technologies. These efficiency gains will have application to buildings constructed before 2025 resulting in a substantial reduction in energy use throughout the sector.

This involves research, development, demonstration, and technology transfer activities in partnership with industry, government agencies, universities, and national laboratories.

BT has identified a three-strategy approach to overcome barriers and achieve the goal of Zero Energy Buildings (ZEB) by 2025.

1. Research and Development
2. Regulatory Activities
3. Technology Validation and Market Introduction

Key outputs for the next five years under each strategy are listed below:

Research and Development:

- For residential buildings, five technology packages that can reduce energy consumption in new buildings by at least 40%.
- In commercial buildings, key technology pathways to achieve 30% to 50% reduction in purchased energy in new, small commercial buildings relative to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 90.1-2004.
- Continued development of white-light, solid-state lighting, reaching a commercial efficacy of 100 lumens per watt by 2011.

- An improved EnergyPlus, which can evaluate 90% of the state-of-the-art technologies under development by BT R&D.

Regulatory Activities:

- Test procedures—which can include procedures for measuring energy efficiency and/or water-use efficiency, definitions, and/or test sampling, compliance certification, and enforcement requirements—for torchieres, ceiling fans, commercial reach-in refrigerators, vending machines and beverage merchandisers, and incandescent reflector lamps
- Final rules for performance standards for distribution transformers, commercial unitary AC/HP, furnaces and boilers, and ASHRAE products
- Upgraded 2009 International Energy Conservation Code to include improved lighting, envelope, and mechanical requirements

Technology Validation and Market Introduction:

- New criteria for clothes washers and dishwashers, and the expansion of the program to include water heaters, solid-state lighting, and other emerging products

Translating Building Technologies Program Goals into Market Outcomes

The details of how the outputs of the Building Technologies Program are translated into market outcomes—many of which are determined offline (outside) the integrated energy market models—are summarized in the appendices of this report.

Individual Program Case Results for Building Technologies Program

The Building Technologies Program's array of R&D and deployment activities are projected to result in energy savings primarily in four end-use categories: space heating, space cooling, water heating, and lighting. **Figure 3.10** demonstrates the level of delivered energy savings (excluding losses from electricity generation) from each category. The stacked area plots show delivered energy use for each end-use category under the base and program cases for the BAU scenario. The yellow bars show the difference in delivered energy use between the base case and the program case.

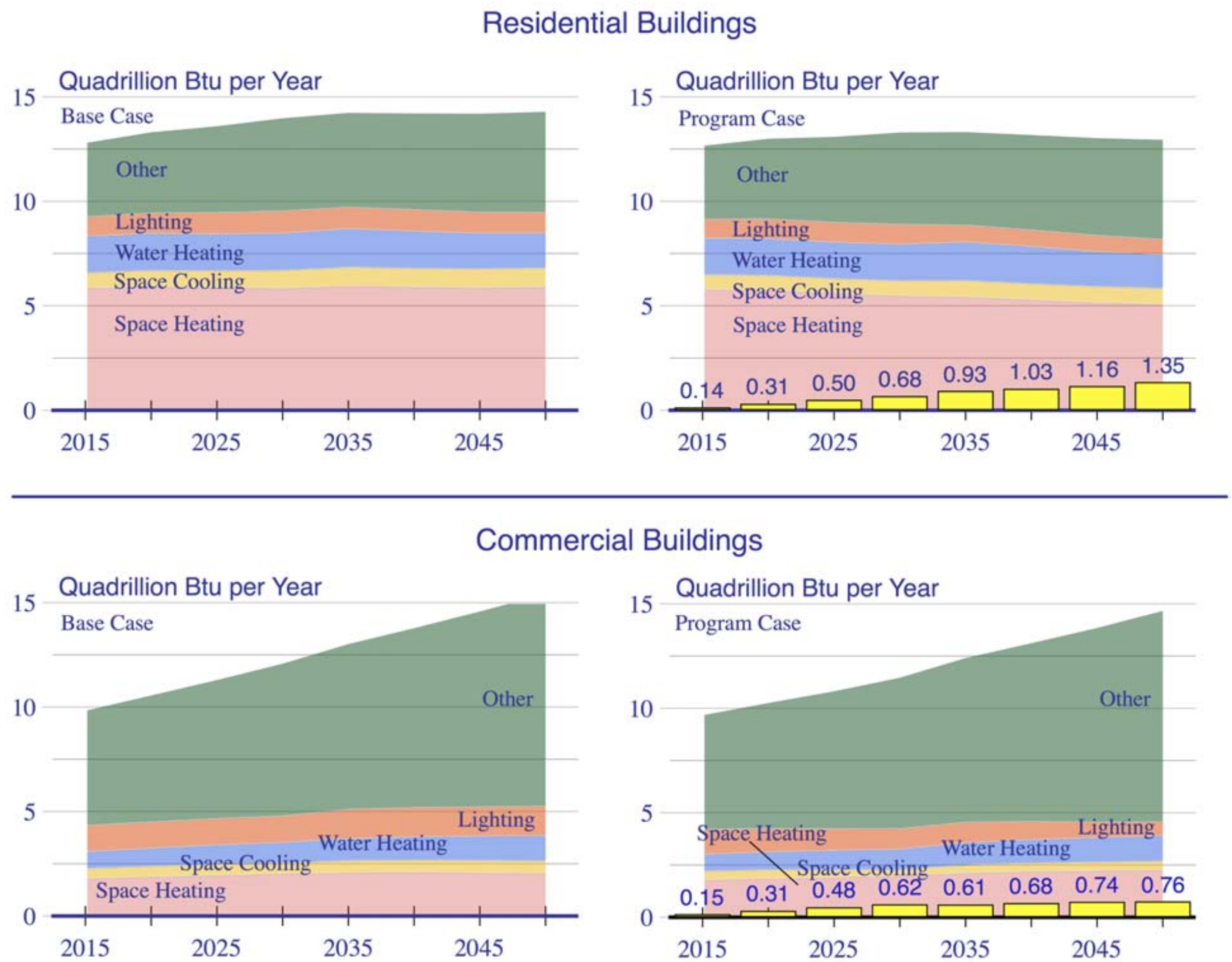


Figure 3.10. Delivered Energy Use in Commercial and Residential Buildings by Type

Table 3.3 summarizes the benefits for the individual Building Technologies Program case under the BAU scenario. The Building Technologies Program benefits are estimated within the integrated energy models, even for those elements where market impacts are estimated offline, so that the electricity-generation primary energy savings are directly computed. In addition, the integrated results include any feedbacks in the buildings or other sectors resulting from changes in energy prices that result from the reduced energy consumption. Cumulative consumer savings (on a net present value basis in the year 2008) are $120 billion by 2030, and reach $900 billion by 2050. Consumer savings result from lower energy bills due to efficiency improvements that exceed the investment costs of those improvements. A secondary effect of lower natural gas prices also contributes to savings. Energy system cost savings reach $107 billion by 2050. Reduced energy consumption leads to reductions in carbon emissions and reduces the cost for meeting criteria pollutant caps applicable to power generation. By 2030, cumulative carbon emission reductions are more than 600 million metric tons of carbon, and reach more than 2 billion metric tons in 2050.

Table 3.3. FY08 Benefits Estimates for the Building Technologies Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	0%	1%	1%	1%	2%	1%	2%	4%	1%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	78	88	96	107
Consumer Savings, Annual (bil $2004)	2	5	8	16	27	60	72	84	71
Consumer Savings, NPV (bil $2004) 2/	2	16	36	72	121	514	648	785	899
Electric Power Industry Savings, Annual (bil $2004) 3/	1	3	7	12	18	16	19	20	17
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	1	10	30	61	101	134	169	204	232
Reduction in Fraction of Household Income Spent on Energy	0.1%	0.2%	0%	1%	1%	1%	1%	2%	1%
Reduced Energy Intensity of Economy (Percent)	0%	1%	1%	2%	2%	2%	3%	3%	3%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	3	10	32	47	57	72	79	78	77
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	7	44	150	348	621	1023	1404	1795	2181
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	ns	ns	2	4	5	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	ns	0.1	0.1	0.1	0.1	0.1	0.1
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	ns	0	0	1	1	1
Security Fuel Economy Improvement (MPG)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	ns	ns	ns	ns	ns	ns
Reduced Oil Intensity (Percent)	ns	ns	ns	0.6%	0.6%	0.5%	0.5%	0.4%	0.4%

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
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5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

Federal Energy Management Program

The Federal Energy Management Program (FEMP) strives to enhance energy security, environmental stewardship, and cost reduction within the Federal Government by advancing energy efficiency and water conservation; promoting the use of renewable energy, alternative fuels in Federal vehicle fleets, sustainable building design, and distributed energy resources; and improving utility management decisions at Federal facilities.

FEMP pursues its mission through integrated activities to improve the energy efficiency of, and renewable energy use by, the Federal Government. These improvements reduce the energy intensity at Federal facilities, lower their energy bills, and provide environmental benefits. Additionally, building energy efficiency technologies provide less easily quantifiable benefits, such as improved lighting quality and building occupant productivity. The benefits estimates reported exclude any expected acceleration in the deployment of the technologies that may result from “spillover” to state or local office buildings.

In addition to the benefits quantified, improved Federal energy management increases the ability of the Federal Government to manage its energy loads during emergencies, and facilitates coordination of Federal energy use with local authorities in the event of local energy supply constraints or emergencies.

Annual outputs of the program are summarized in **Table 3.4**.

Table 3.4. Anticipated FEMP Annual Outputs, Activities, and Milestones

Outputs	Associated Activities	Associated Milestones
Project Financing Activities (Annual)	Key activities 1. Energy Savings Performance Contracts (ESPC) 2. Utility Energy Savings Contracts (UESC) 3. Energy Markets/Shared Energy Savings Support	Complete project financing activities that will result in life-cycle Btu savings of 14.9 trillion annually.
Technical Assistance Activities (Annual)	Key activities 1. Technical Assistance Projects (TA) 2. Renewable Energy Purchases	Complete technical assistance activities that will result in life-cycle Btu savings of 4.7 trillion and support renewable energy purchases of 0.6 trillion Btu annually.

Translating FEMP Goals and Program Outcomes into Energy Model Parameters

Projected annual energy savings for FEMP are estimated offline, and provided directly as inputs to the integrated energy models (see **Figure 3.11**).

Individual Program Case Results for the FEMP Program

Benefits of the Federal Energy Management Program (FEMP) are summarized in **Table 3.5**. It 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. Because the program is targeted to a small segment of the energy system, the savings are modest relative to other EERE programs. By 2030, cumulative carbon emission reductions are 11 MMTCE, and the consumer savings (primarily commercial-building energy users) are $7 billion on a net present value basis. By 2050, cumulative carbon emission reductions and cumulative consumer savings reach levels of 35 MMTCE and $19 billion, respectively.

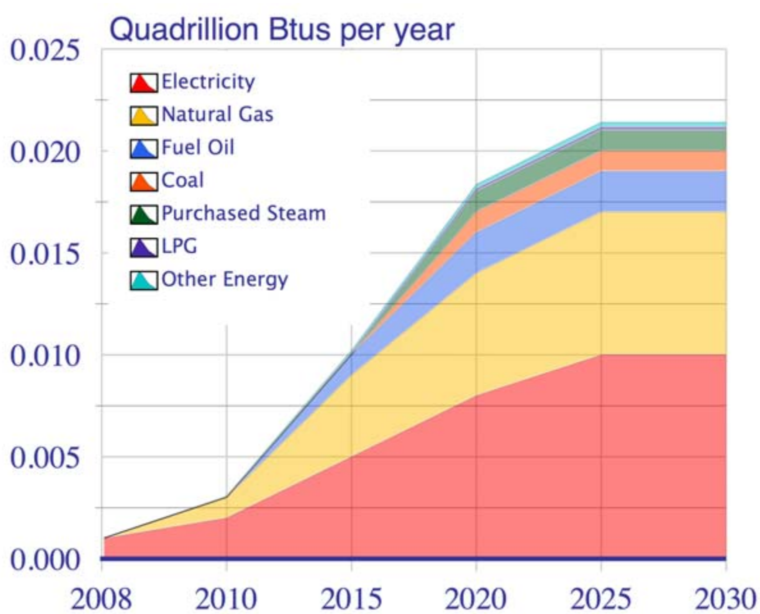


Figure 3.11. Cumulative Energy Savings Associated with FEMP

Table 3.5. FY08 Benefits for the Federal Energy Management Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	ns	ns	ns	ns	ns	0%	0%	0%	0%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	2	2	2	2
Consumer Savings, Annual (bil $2004)	0	0	0	0	1	1	1	1	1
Consumer Savings, NPV (bil $2004) 2/	0	1	2	2	4	13	15	17	19
Electric Power Industry Savings, Annual (bil $2004) 3/	0	0	0	0	0	0	0	0	0
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	0	0	1	1	2	3	4	4	5
Reduction in Fraction of Household Income Spent on Energy	0%	0%	0%	0%	0%	0%	0%	0%	0%
Reduced Energy Intensity of Economy (Percent)	0%	0%	0%	0%	0%	0%	0%	0%	0%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	0	0	1	1	1	1	2	1	1
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	0	1	3	7	11	17	23	30	35
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	ns	ns	ns	ns	ns	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	ns	ns	ns	ns	ns	ns
Security Fuel Economy Improvement (MPG)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	ns	ns	ns	ns	ns	ns
Reduced Oil Intensity (percent)	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

Hydrogen, Fuel Cells, and Infrastructure Technologies Program

The Hydrogen, Fuel Cells, and Infrastructure Technologies (HFCIT) Program conducts research and development activities in hydrogen production, storage, and delivery; and transportation and stationary fuel cells. On the demand side, the program's activities focus on the introduction of fuel cells for both stationary and mobile applications. On the supply side, the program goal is to lower the production cost of hydrogen to a competitive level against petroleum products.

Success for the HFCIT Program is defined as validation, by 2015, of technology for:

- Hydrogen storage systems enabling greater than 300-mile vehicle range, while meeting identified packaging, cost, and performance requirements.
- Hydrogen production from diverse pathways to safely and efficiently deliver hydrogen to light-duty hydrogen fuel cell vehicles, cost-competitively on a per-mile basis without adverse environmental impacts.
- Fuel cells to enable engine costs of less than $50/kW (in high-volume production) and stationary power production at $400-$700/kW, while meeting performance and durability requirements.

Details of the program's activities, milestones, and outputs are described in various source documents, such as the program's multiyear plan and in the appendices to this report. If these indicators are met, there is a high probability of success that customer requirements can be met, and that industry will begin to realize a business case for proceeding with the implementation of the hydrogen infrastructure and fuel cell vehicles. While the full extent of life-cycle cost and energy and environmental impacts will not be achieved for decades, meeting the Technology Readiness Milestone in 2015 will begin to yield national benefits as early as 2025.

Translating HFCIT Goals into Energy Model Parameters

No individual benefits for the Hydrogen, Fuel Cells, and Infrastructure Technologies Program were computed in NEMS-GPRA08 for the midterm. NEMS-GPRA08 currently does not have a full representation of hydrogen supply (although under development by EERE). A simplified representation was included as part of the EERE Portfolio.

The representation of the Hydrogen, Fuel Cells, and Infrastructure Technologies Program in MARKAL-GPRA08 requires representation of fuel cell vehicles and transportation markets, hydrogen production and distribution infrastructure, and stationary fuel cell applications. The following sections highlight a few examples of inputs that were developed. A more comprehensive discussion of how baseline and program case assumptions were developed is available in the appendices of this report.

Stationary Fuel Cells: A review of the *AEO2006* assumptions and the HFCIT Program goals revealed differences in installed costs and the unit efficiencies. After adjusting for installation costs, there remains a difference in the view of current (or nearly current) technology that might reflect different trade-offs of efficiency and costs, or may reflect differences in development. A recent status review of the stationary fuel cell goals by the Hydrogen Program Fuel Cell team identified current technology information for the efficiencies and costs, which have been used for this analysis. **Figure 3.12** compares the *AEO2006* and HFCIT Program assumptions about base case projections for capital costs of residential and commercial building stationary fuel cells. While the rates of progress in the base case are similar between the *AEO2006* and program assumptions, the HFCIT Program estimates significantly lower current capital costs. Success in the HFCIT program brings capital costs down much more rapidly.

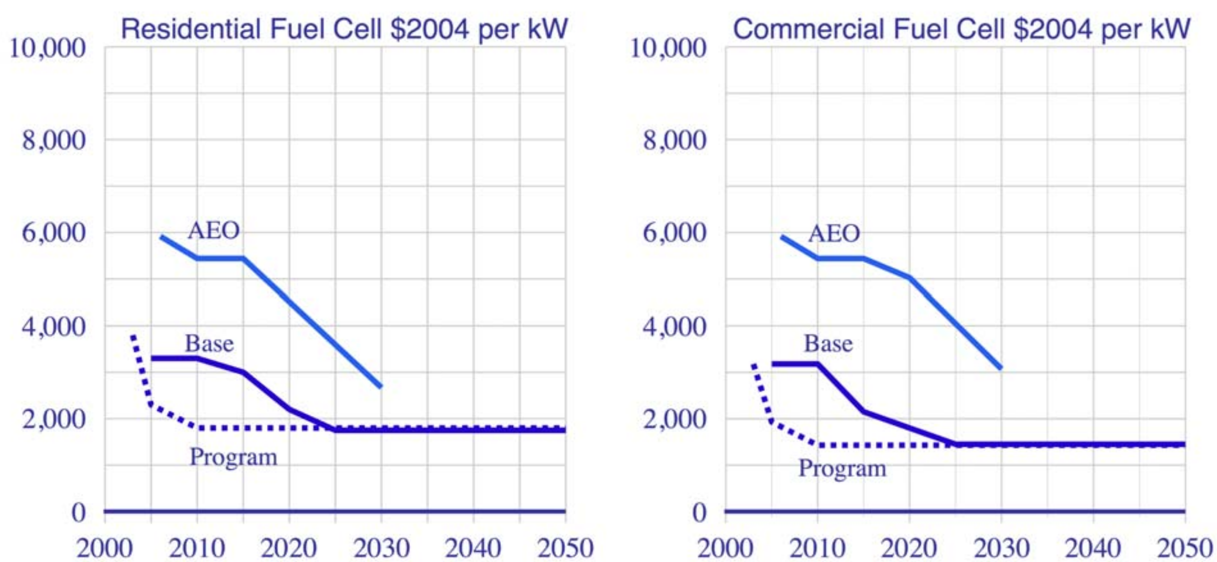


Figure 3.12. Projected Capital Cost of Stationary Fuel Cell Systems for the *AEO2006* Reference, GPRA Base, and GPRA HFCIT Program Cases

Fuel cell vehicles and transportation markets: Fuel cell vehicles are projected to compete with traditional petroleum and hybrid-electric vehicles for market share in the light-duty vehicle (LDV) and commercial light-truck markets. In MARKAL-GPRA08, analysts measure energy service demands for road transportation in vehicle miles traveled (VMT). Projected VMTs are taken directly from the *AEO2006* and extended past 2030, based on historical relationships between passenger car and light-truck VMTs and population. LDV VMTs are further disaggregated into three market segments based on population data for Core Based Statistical Areas (CBSAs). The market segments are defined as follows:

- Large City – Population greater than 250,000
- Medium City – Population between 25,000 and 250,000
- Rural – Population under 25,000

Projected VMTs for light-duty vehicles are shown in **Table 3.6**.

Table 3.6. Light-Duty Vehicle Miles Traveled (billion VMTs/year)

	2020	2025	2030	2035	2040	2045	2050
Large City	2,329	2,542	2,770	2,957	3,156	3,265	3,376
Medium City	713	779	849	906	967	1,000	1,034
Rural	439	479	523	558	595	616	637

The Hydrogen Program Case was constructed assuming both HFCIT and modified advanced conventional and hybrid vehicle assumptions; and is compared to a baseline with the advanced conventional vehicles and hybrids. The rationale for this approach is that the hydrogen fuel cell vehicle assumptions provided by the HFCIT Program assume that the Vehicle Technologies Program's hybrid systems and materials technologies R&D activities are successful. Note that these "modified" advanced conventional and hybrid vehicles are not as efficient as those modeled in the Vehicle Technologies Program, because they are not assumed to use other Vehicle Technologies Program R&D goals for fuel combustion or deep discharge battery improvements.

Hydrogen production and distribution infrastructure: The HFCIT Program conducts research on developing cost-effective hydrogen production technologies from distributed natural gas reformers, as well as a variety of renewable sources, including biomass. For the EERE Hydrogen Case, analysts modeled nine hydrogen production technologies: distributed natural gas reformers, central natural gas reformers, central coal gasification (with and without cogeneration), central biomass gasification, distributed ethanol reformers, central electrolytic production (both grid electricity and wind-dedicated electrolysis), and distributed electrolytic production. Other renewable hydrogen-production technologies were not modeled, due to a greater degree of uncertainty in their costs. Nuclear hydrogen production technologies were not modeled as part of the EERE HFCIT Program, but were represented in the Office of Nuclear Energy (NE) GPRA analysis. We expect that more hydrogen production technologies will be modeled in future GPRA analyses, as the data becomes available.

Carbon sequestration pathways were available for central coal and natural gas hydrogen production. However, because no carbon policies were assumed in the business-as-usual (BAU) scenario, producers would not have an economic incentive to incur the incremental cost to sequester carbon generated from hydrogen production activities; and, thus, no carbon was sequestered in the BAU Program Case.

HFCIT Program goals were used to estimate capital and O&M costs and production efficiencies for distributed natural gas reformers, central biomass gasifiers, distributed ethanol reformers, and central and distributed electrolytic production technologies. Assumptions for central coal and natural gas production technologies were adapted from H2A analysis results. The infrastructure requirements and operating costs for the widespread distribution of hydrogen vary widely by distance and method. The program provided estimated hydrogen distribution costs by market size and market penetration. The HFCIT Program's goal is to reduce the cost of distributing hydrogen from central production facilities to consumers to $1 per kilogram. However, the program does not expect the required infrastructure to be in place until 2030, at the earliest. For GPRA08, analysts assumed that distribution costs would fall to program goals in large and medium cities by 2030 and 2035, respectively. Rural markets were assumed to be served only by distributed hydrogen production technologies.

Individual Program Case Results for HFCIT Program

Figure 3.13 shows the projected distribution of light-duty vehicle (LDV) technologies resulting from success in the HFCIT Program under the Business-as-Usual (BAU) scenario, as well as success in developing advanced conventional and hybrid vehicle technologies (see discussion in previous section). The first hydrogen fuel cell vehicles begin to appear after 2020. By 2030, hydrogen fuel cell vehicles are 5% of the LDV fleet—reaching a level of 36% by 2050. **Figure 3.13** also shows the advanced vehicle technologies case without the HFCIT Program. This case is used as the baseline for calculating benefits of the HFCIT. A comparison of the two charts shows that the HFCIT Program case takes away substantial LDV fleet share from the advanced gasoline hybrids, with fewer—but still significant—effects on advanced conventional vehicles and plug-in hybrid vehicles. In both cases, conventional gasoline vehicles in the fleet are gone by 2050.

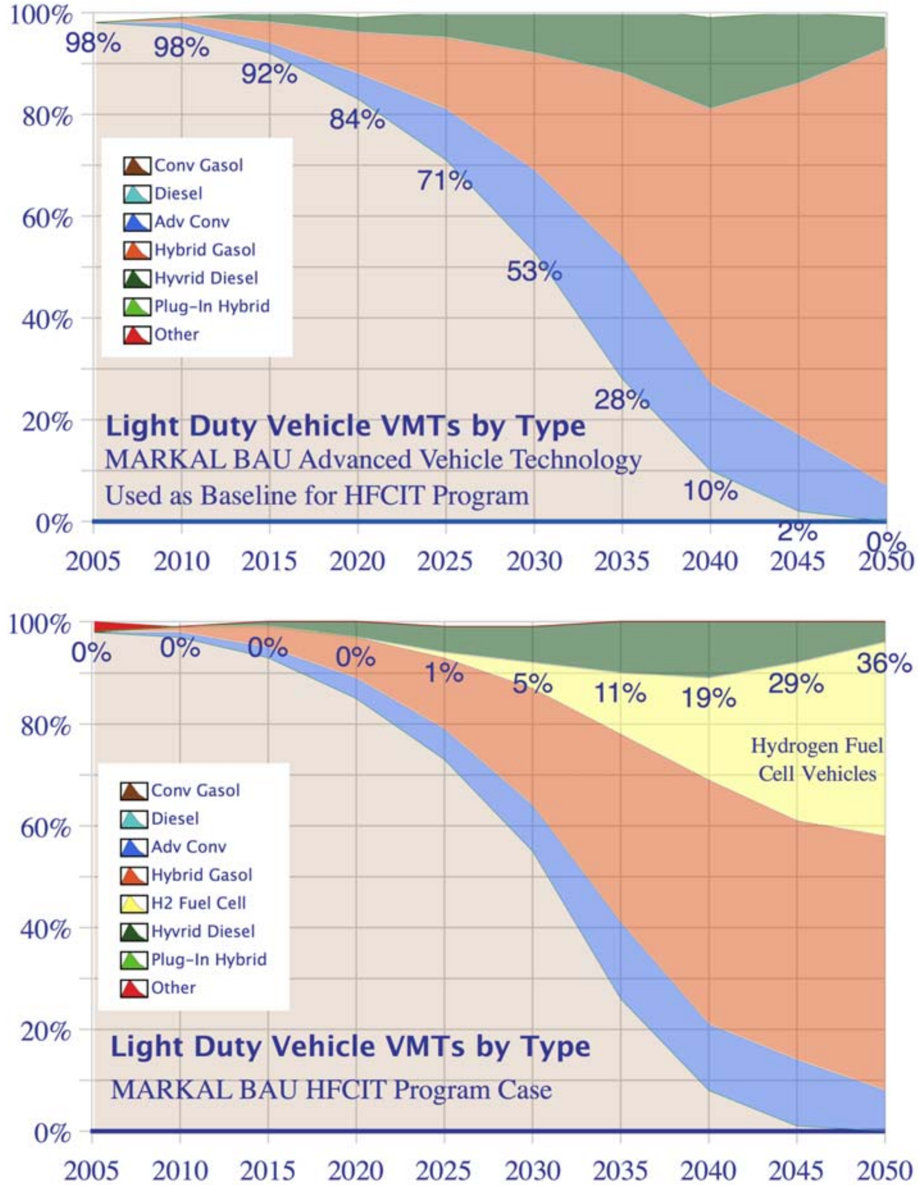


Figure 3.13. Projected Hydrogen Fuel Cell Vehicle Market Penetration

Table 3.7 summarizes the benefits of the HFCIT program through 2050. The impacts of the HFCIT Program are not seen until after 2025. During certain periods at the beginning, or shortly after deployment of HFCIT technology, costs to consumers and the electric power sector and natural gas prices actually increase. Energy system cost savings—a proxy for consumer and producer surplus—is always positive. After 2030, the HFCIT Program results in substantial environmental benefits in the form of avoided greenhouse gas emissions. Security benefits are also substantial throughout this period. Avoided oil imports increase from 0.3 million to 2 million barrels per day between 2030 and 2050. In the transportation sector, the security fuel economy of light-duty vehicles improves by 63 miles per gallon of oil consumed by 2050. Diversity of the fuel supply for transportation improves by almost 40% at its peak in 2045.

Table 3.7. FY08 Benefits for the Hydrogen, Fuel Cell, and Infrastructure Technologies Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 7/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	0%	0%	0%	0%	-3%	-7%	-4%	0%	-3%
Energy System Cost Savings (bil $2004) 1/	ns	ns	ns	ns	$0	$1	$5	$8	$10
Consumer Savings, Annual (bil $2004)	ns	ns	ns	3	5	-48	10	51	80
Consumer Savings, NPV (bil $2004) 2/	ns	ns	ns	8	19	-41	-69	-10	92
Electric Power Industry Savings, Annual (bil $2004) 3/	ns	ns	ns	-2	-3	-6	1	9	10
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	ns	ns	ns	-8	-14	-25	-28	-18	-4
Reduction in Fraction of Household Income Spent on Energy	0%	0%	0%	0%	0%	0%	1%	1%	2%
Reduced Energy Intensity of Economy (Percent)	0%	0%	0%	0%	0%	1%	1%	2%	2%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	ns	ns	ns	-3	14	24	29	30	31
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	ns	ns	ns	-20	16	114	248	396	551
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	nr	nr	nr	nr	nr	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	0.0	0.0	0.3	0.9	1.4	1.9	2.1
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	0	0	0	2	4	7	11
Security Fuel Economy Improvement (MPG)	ns	ns	0	0	1	5	10	25	63
Transportation Fuel Diversity Improvement (percent) 6/	0%	0%	2%	6%	15%	27%	33%	37%	34%
Reduced Oil Intensity (Percent)	ns	ns	ns	ns	2%	5%	7%	10%	13%

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm and long-term benefits based on MARKAL-GPRA08 model. No detailed modeling was done in NEMS-GPRA08.
nr = not reported or calculated by model
ns = not significant relative to model error

Industrial Technologies Program

The Industrial Technologies Program (ITP) will continue its mission of supporting the development of energy-efficient, clean manufacturing technologies by partnering with the industrial sector. ITP has embraced leaner and more agile operating practices to lower industrial energy intensity with reduced resources. By analyzing opportunities, coordinating with other EERE programs, and dynamically refocusing activities, ITP will leverage the current FY 2008 budget request to boost energy efficiency in a sector whose current energy use is approximately 33 quadrillion Btu, one-third of the U.S. total.

In view of the existing challenges, trends, opportunities, and resources, ITP plans to re-examine some aspects of its technology R&D portfolio such as:

- Research alternatives for natural gas to reduce vulnerability to critical supply and price volatilities, with a focus on energy-intensive industries such as chemicals and steel.
- Identification of crosscutting research opportunities for melting, high-temperature processing, fabrication, and forming of ferrous and nonferrous metals and glass.
- Expansion of current research to address technical challenges in energy conversion systems (e.g., Super Boiler, waste heat recovery), separations (e.g., advanced drying), and alternative chemical reactions.
- Exploring next-generation manufacturing concepts to respond to strategic needs and to produce transformational outcomes that enhance U.S. technological leadership.

The budget request calls for a transition in ITP's program planning unit structure beginning in FY 2008 from one focused on R&D addressing (1) specific vision industries of the future, (2) crosscutting R&D, and (3) technical assistance [including Industrial Assessment Centers (IAC) and Best Practices] to a more explicitly crosscutting structure with three new R&D program components:

- Energy-Intensive Process R&D
- Fuel and Feedstock Flexibility
- Interagency Manufacturing R&D

ITP will allocate new FY 2008 projects among these program components, and will phase out funding for the industry-specific planning unit projects as each project is completed. It is expected that transition to the new crosscutting planning structure will be completed within two to three years. However, GPRA08 benefits are necessarily based on analysis of the FY 2007 program portfolio, because the specific content of the FY 2008 portfolio is as yet unknown.

Translating Industrial Technologies Program Goals into Energy Model Parameters

Because of the level of complexity in the range of technologies and industries covered by ITP, the estimation of market outcomes associated with the program's outputs is done offline. Details of the analysis are available in the appendices to this report.

Individual Program Case Results for the Industrial Technologies Program

Table 3.8 summarizes the benefits of the ITP through 2050. The Industrial Technologies Program accelerates the development and adoption of efficient technologies. Because the private sector would likely eventually adopt the same or similar technologies at a later time, even in the absence of the program, the benefits that accrue to the program begin to shrink in the later years as the private-sector savings "catch up" in the baseline. Energy savings from the Industrial Technologies Program, relative to the baseline, peak in 2025, this reduces the energy intensity of the economy by 2%. As a result of lower energy use, carbon emissions are reduced by 43 MMTCE per year in 2025. Cumulative carbon emission reductions are almost 600 MMTCE in 2030 and 800 MMTCE in 2050. The cost of energy to industry and all other energy consumers is reduced by $97 billion on an NPV basis by 2030 and $243 billion by 2050, due to lower energy consumption and slightly lower energy prices. Oil import reductions are not very significant.

Table 3.8. FY08 Benefits for the Industrial Technologies Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	ns	ns	1%	2%	0%	2%	1%	1%	0%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	13	10	7	6
Consumer Savings, Annual (bil $2004)	1	4	9	14	11	14	10	7	7
Consumer Savings, NPV (bil $2004) 2/	2	12	37	73	97	195	219	233	243
Electric Power Industry Savings, Annual (bil $2004) 3/	0	1	2	3	3	3	2	1	2
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	0	3	9	17	22	52	57	59	62
Reduction in Fraction of Household Income Spent on Energy	ns	ns	ns	ns	ns	0%	0%	0%	0%
Reduced Energy Intensity of Economy (Percent)	0%	1%	1%	2%	2%	1%	1%	1%	1%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	4	15	31	43	40	25	20	17	18
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	8	59	174	362	567	503	614	705	791
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	ns	ns	ns	ns	ns	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	ns	ns	ns	ns	ns	ns
Security Fuel Economy Improvement (MPG)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	ns	ns	ns	ns	ns	ns
Reduced Oil Intensity (percent)	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

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. 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.

The President's Solar America Initiative (SAI) was launched January 2006, as part of the Administration's Advanced Energy Initiative, and is being led by the U.S. Department of Energy (DOE) Solar Energy Technologies Program (SETP). The primary mission of the SAI is to reduce the cost of photovoltaic (PV) technologies so PV-generated electricity is cost-competitive with conventional electricity sources by 2015. An analysis of projected market prices for electricity was used to establish technology targets consistent with this goal (see **Table 3.9**). These targets are based on Energy Information Administration (EIA) projections of relatively flat electricity prices (in real terms) over this time period, based on current conventional fuels. The 2005 Benchmark levelized cost-of-energy (LCOE) of PV systems and target projections are based on SETP internal analyses and the U.S. PV Industry Roadmap. With the ultimate goal for SAI being cost parity with grid-generated electricity, SETP will revise these targets over time as new information warrants.

Table 3.9. Cost Targets for Grid-Connected PV Systems in Key Market Sectors

Market Sector	Current U.S. Market Range (c/kWh)	Solar Electricity Cost – Current and Projected (c/kWh)		
		Benchmark	Target	
		2005	2010	2015
Residential	5.8-16.7	23-32	13-18	8-10
Commercial	5.4-15.0	18-22	9-12	6-8
Utility	4.0-7.6	15-22	10-15	5-7

The SAI enhances DOE's business strategy of partnering with U.S. industry to accelerate commercialization of improved PV systems that can meet aggressive cost and installed-capacity goals. Complementing the core R&D and engineering activity of the SAI are technology acceptance activities aimed at reducing market barriers and promoting market expansion of solar energy technologies through non-R&D activities.

The SAI will drive toward accelerated commercialization of solar photovoltaic systems to a milestone in 2015, at which time they will be competitive with conventional sources of electricity in all domestic grid-tied market sectors: residential, commercial, and utility-scale markets. The main goals of this nine-year mission are:

- Substantively accelerate development of U.S.-produced PV systems, so that PV-produced electricity reaches parity with the cost of electricity in select grid-tied target markets across the nation.
- Expand the U.S.-installed domestic capacity of PV systems to 5-10 gigawatts (GW) by 2015.

To implement the SAI, the SETP will pursue an R&D strategy that is segmented into three manageable three-year phases. These phases will progressively reduce the cost of commercially available PV systems and components, and will ultimately yield commercial products and production processes that achieve the LCOE targets and support installed-capacity targets by 2015. The first three-year phase is scheduled to run from early calendar year (CY) 2007 through early CY 2010; the second three-year phase is expected to run from early CY 2010 through early CY 2013; and the third three-year phase is expected to run from early CY 2013 through the end of CY 2015.

Translating SETP Goals into Energy Model Parameters

The Solar Program Case assumptions for the cost of PV systems are shown in **Table 3.10**. They are consistent with the market targets shown in **Table 3.9**.

Table 3.10. Technology Cost Inputs to NEMS-GPRA08 and MARKAL-GPRA08 for PV Systems in Solar Program Case

	Central Generation		Residential Buildings		Commercial Buildings	
Year	Installed Price (2003$/kW)	O&M (2003$/kW)	Installed Price (2003$/kW)	O&M (2003$/kW)	Installed Price (2003$/kW)	O&M (2003$/kW)
2005	5,500	20	8,500	100	6,290	40
2010	3,900	10	5,000	40	4,000	20
2015	2,580	6	3,300	20	2,210	10
2020	2,193	5	2,805	17	1,879	9
2025	1,974	5	2,525	15	1,691	8
2030	1,875	4	2,398	15	1,606	7
2050	1,781	4	2,278	14	1,526	7

Note: These characteristics are for California plants and will vary by region within the integrated energy models.

The cost targets for CSP technology in the Solar Program case are shown in **Table 3.11**. These targets are based on a funding level consistent with the FY07 budget request for FY07, and a funding level commensurate with those outlined in the Draft CSP Technology Transition Plan for years beyond FY07.

Table 3.11. Technology Cost Inputs to NEMS-GPRA08 and MARKAL-GPRA08 for CSP Systems in Solar Program Case

Year	Installed Price (2003$/kW)	O&M (2003mills/kWh)	Capacity Factor
2010	3,510	7.8	65%
2020	2,462	4.0	72%
2025	2,199	3.6	72%
2030	1,993	3.2	72%
2035	1,879	3.1	72%
2040	1,826	3.0	72%
2050	1,797	2.9	72%

In addition to these program case inputs, analysts for the SETP have developed alternative base case projections for PV system costs. **Figure 3.14** compares the *AEO2006* reference case, the revised base case, and the program case installed cost projections for residential and commercial PV. For PV technology, the baseline (No DOE RD3 Case) cost projections are very similar to the projections in the *AEO2006* reference case, which were based on the baseline scenario in the *U.S. PV Industry Roadmap* (see the Solar Program appendix for detailed reference information). While the PV industry roadmap baseline scenario included the PV program funded at the pre-SAI level, i.e., roughly half the SAI funding level, the U.S. and global PV industry has gained considerable momentum during the past couple of years. Thus, our GPRA08 baseline cost projections take this momentum into account. Based on the program's benchmarked estimates, we assume that the cost of PV in 2005 is higher than in the *AEO2006*; however, by 2015, the projected GPRA08 baseline costs are roughly equivalent to the *AEO2006* projections. The overlap remains relatively close through 2030. Beyond 2030, the costs continue to decline, but at a relatively modest rate through 2050, ending slightly below the baseline PV industry roadmap projection. Thus, our baseline cost projection is consistent with the *AEO2006* reference case and PV industry roadmap baseline scenario. For CSP technology, the Solar Program Baseline simply used the *AEO2006* Reference Case projection for CSP systems characteristics and costs. More details on the full set of adjustments made to the *AEO2006* reference case are available in the appendices to this report.

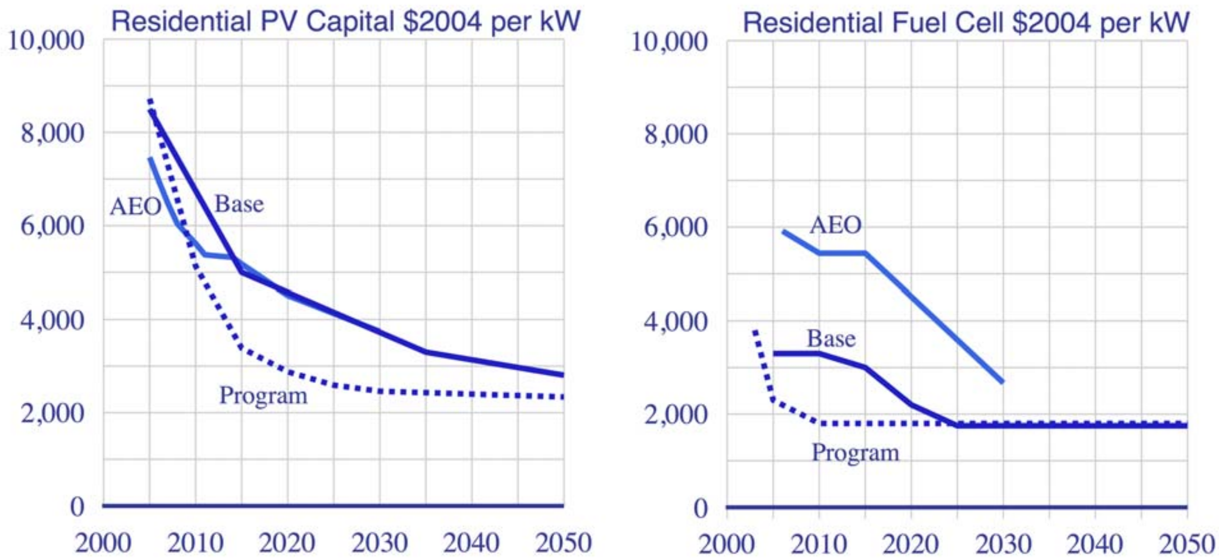


Figure 3.14. Projected Capital Cost of PV Systems for the AEO2006 Reference, GPRA Base, and GPRA Solar Program Cases

Individual Program Case Results for Solar Energy Technologies Program

Figure 3.15 summarizes projected solar electricity capacity in the base and program cases. With the success of the EERE's RD3 efforts, PV systems are projected to become much more cost-effective—especially in distributed (rooftop) applications—and enjoy more widespread adoption. By 2020, the capacity of installed PV systems is projected to increase from only 1 GW in the Baseline to 17 GW in the Individual Program Goal Case. By 2030, total installed PV is projected to increase to 76 GW, or 57 GW above the baseline. By 2030, 4 GW of CSP capacity is anticipated; bringing the total incremental solar power capacity associated with the Solar Program up to 61 GW. By 2050, total installed PV is projected to increase to 258 GW. CSP capacity in 2050 is 27 GW, bringing the total solar capacity in 2050 under the program case to 285 GW—almost 190 GW over the baseline case. Incremental benefits of the program peak in 2045, as the baseline case begins to add significant amounts of distributed PV capacity.

Benefits of the Solar Energy Technologies Program are shown in **Table 3.12**. Economic and environmental benefits result from increased PV and CSP generation. Annual carbon emissions are projected to be reduced by 23 MMTCE by 2030 and by 177 MMTCE on a cumulative basis from 2008. By 2050, avoided carbon emissions climb to 50 million metric tons of carbon per year, and a cumulative reduction of 1 billion metric tons of carbon. Energy-expenditure savings are measured as the reduction in consumer expenditures for electricity and other fuels offset by increased consumer investments, such as distributed PV systems. Net consumer savings are not significant for the program through 2030. The electric system costs savings, on the other hand, indicate that the cost of centrally supplied electricity declines as more electricity demand is met with distributed PV. Cumulative electric power savings are projected to be $28 billion and $291 billion on a net present value basis in 2030 and 2050, respectively. Energy system cost savings—a proxy for the consumer and producer surplus—are $6 billion and $9 billion (net present value) in 2035 and 2050.

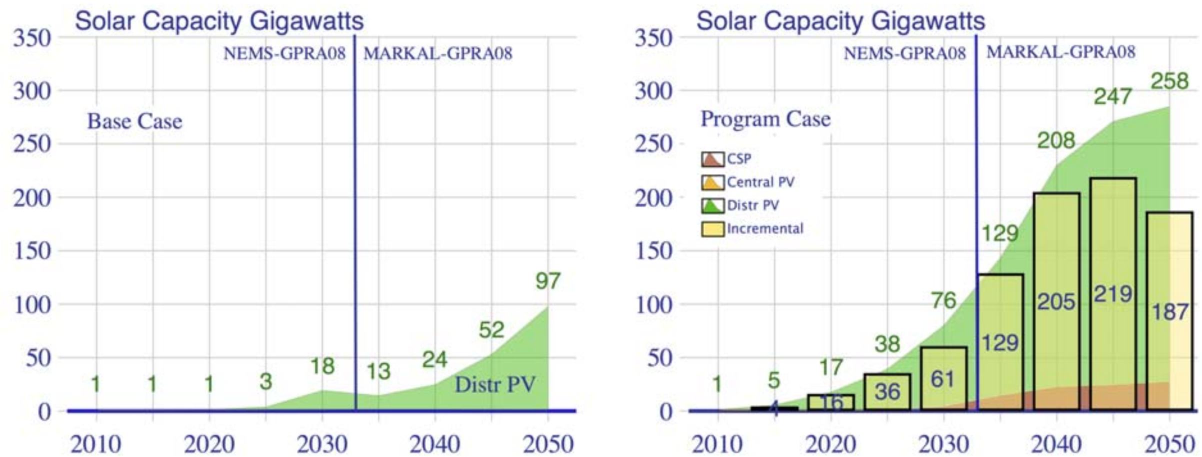


Figure 3.15. Projected Solar Capacity for Base Case and Individual Solar Program Case

Table 3.12. FY08 Benefits for the Solar Energy Technologies Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	ns	ns	ns	ns	ns	6%	10%	9%	1%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	6	8	9	9
Consumer Savings, Annual (bil $2004)	ns	ns	ns	ns	ns	23	52	67	50
Consumer Savings, NPV (bil $2004) 2/	ns	ns	ns	ns	ns	58	138	243	328
Electric Power Industry Savings, Annual (bil $2004) 3/	0	0	1	3	8	27	37	42	31
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	0	0	4	12	28	102	168	238	291
Reduction in Fraction of Household Income Spent on Energy	ns	ns	ns	ns	ns	0%	1%	1%	1%
Reduced Energy Intensity of Economy (Percent)	0%	0%	0%	0%	0%	1%	1%	1%	1%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	0	1	10	12	23	28	47	50	50
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	2	8	33	82	177	359	554	797	1047
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	ns	ns	ns	ns	ns	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	ns	ns	ns	0	0	0	0
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	ns	ns	0	0	0	0
Security Fuel Economy Improvement (MPG)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table notes:
1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

FreedomCAR and Vehicle Technologies Program

The FreedomCAR and Vehicle Technologies Program (FCVT) provides technology-focused research and development activities for 1) improving the energy efficiency of current automobiles and light trucks; and, 2) developing technologies that will transition automobile technology to use no petroleum fuels. These activities could have dramatic effects over the next 30 years as more hybrid-electric vehicles, lightweight materials, low-temperature combustion regimes, and alternative fuels including hydrogen are used. FCVT technology is aimed at light vehicles (cars and light trucks [pickups, SUVs, minivans, and vans]) and at heavy vehicles (medium and heavy trucks and buses).

The activities of the FCVT program fall into four areas, with key outputs that include the following:

Vehicle Systems and Materials Technologies

- 24% heavy truck parasitic losses by 2006
- 18,000 lb. tractor trailer by 2010

Hybrid and Electric Technologies

- $500 25kW battery by 2010

Advanced Combustion Technologies

- 45% engine efficiency for light duty applications by 2010
- 55% engine efficiency for heavy duty applications by 2012

Materials Technologies

- Lightweight vehicle materials and processes by 50% by 2010

Translating FCVT Goals into Energy Model Parameters

See the appendices of this report for a detailed discussion of the development of inputs to the integrated energy models. Vehicle attributes are developed (including cost, efficiency, range, acceleration, and others) for each vehicle type, and then competed within the integrated energy models.

Individual Program Case Results for the FCVT Program

In the midterm, the development of cost-effective, highly efficient light-duty vehicles is projected to lead to a shift over time from conventional gasoline vehicles to hybrids, advanced diesels, and advanced conventional gasoline (includes lightweight materials). As shown in the charts on the left side of **Figure 3.16**, the overall sales share for conventional gasoline light-duty vehicles in 2030 falls from 65% in the Baseline Case to 33% in the Individual Program Goal Case. Among the advanced technology vehicles, the overall share in 2030 for advanced combustion diesel increases from 7% to 16%; for advanced conventional, from 1% to 11%; for gasoline hybrids, from 20% to 17% (in the program case, gasoline hybrid sales share peaks in 2025 at 21%); for diesel hybrids, from 0% to 11%; and for PHEVs, from 1% to 8%.

The distribution of vehicles in the stock of vehicles in the U.S. fleet lags behind the changes in the distribution of vehicles in annual vehicle sales, because purchased vehicles remains in the fleet for years after their initial purchase. The total stock of conventional gasoline vehicles in 2030 falls from 236 million vehicles to 166 million (from 74% to just more than 50% of the total stock) between the two cases. The total stock for advanced-combustion diesel in 2030 increases from 16 million to 33 million vehicles (5% to 10% of the total stock) between the baseline and program case; for advanced conventional gasoline vehicles in 2030 from 9 million to 18 million vehicles (3% to 6% of the total vehicle fleet stock); for gasoline hybrids in 2030, from 33 million to 53 million vehicles (from 10% to 17% of the total stock); for diesel hybrids, from 0.1 million to 24 million vehicles (from less than 0.1% to almost 8%); and, for plug-in hybrids, from 2 million to 8 million vehicles (from 0.7% to almost 3% of the total vehicle fleet stock).

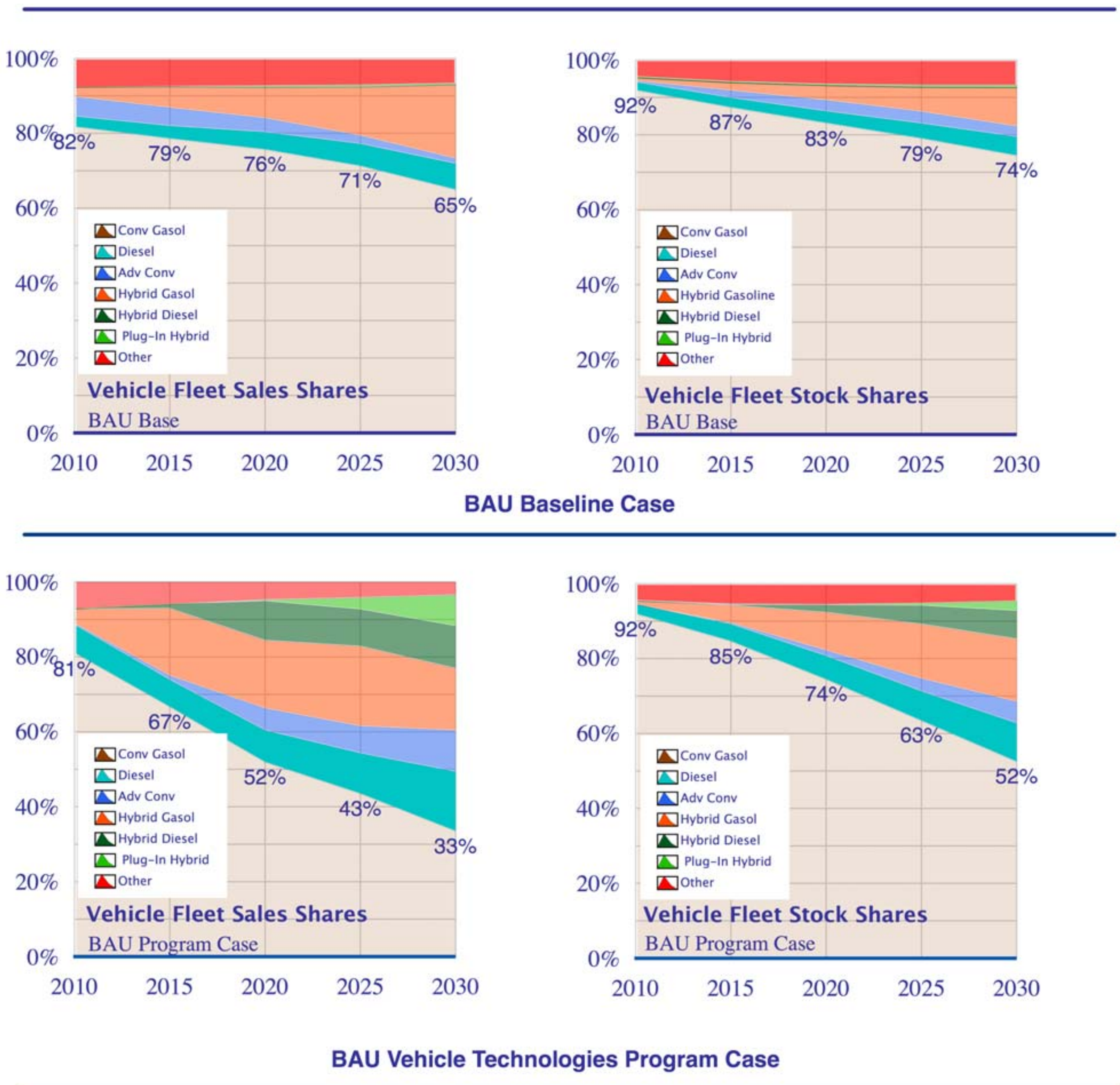
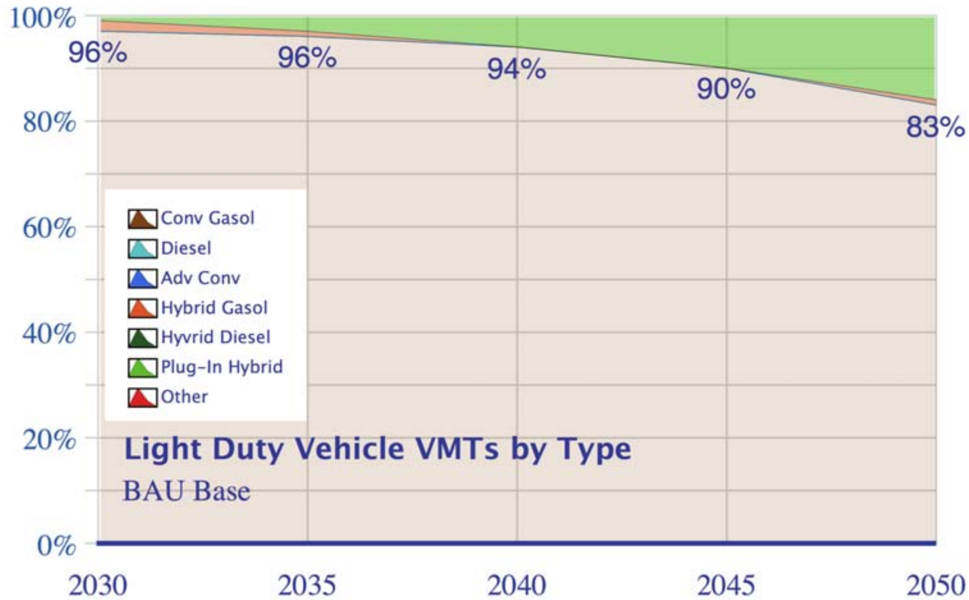


Figure 3.16. Midterm Vehicle Technology Sales and Fleet Stock Shares

NEMS-GPRA08 Model Results

In the long term, conventional gasoline vehicle stock drops dramatically by 2050—from about 80% of the vehicle stock to 5% of the vehicle stock between the baseline and program cases. Advanced diesel engine vehicles increase to about 25% of the total vehicle fleet stock in 2050 between the baseline and program cases. Advanced conventional gasoline vehicles are 5% of the total vehicle fleet stock in 2050 under the program case. Gasoline and diesel hybrids reach peak levels of 31% and 12% in 2045 in the program case. Plug-in hybrid market penetration is significant—achieving more than 50% of the total vehicle fleet stock by 2050.



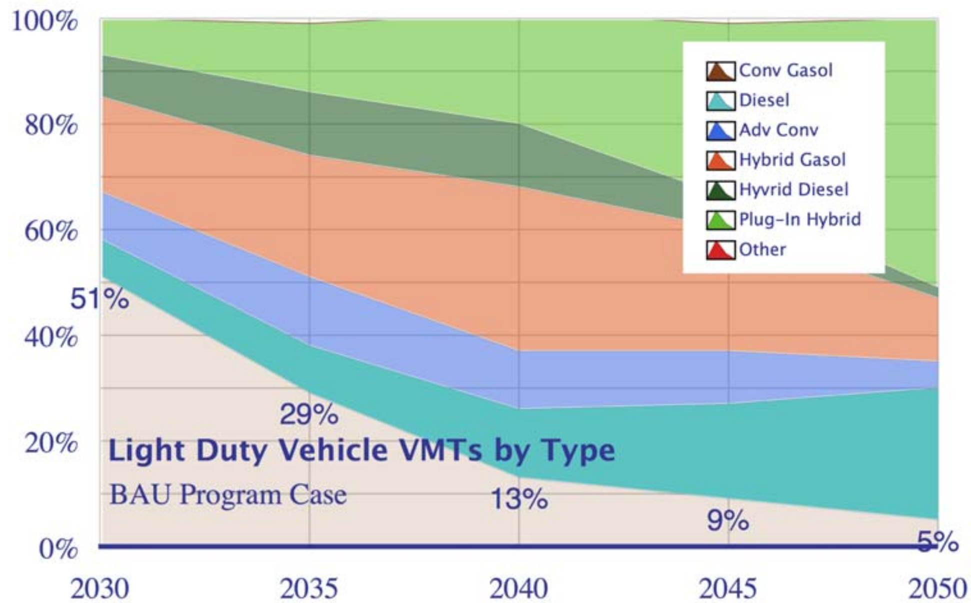
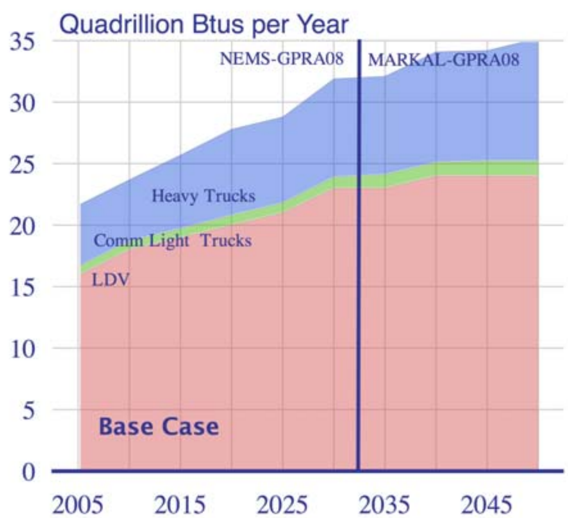


Figure 3.17. Long-Term Light-Duty Vehicle Stocks in BAU Baseline and Vehicle Program Cases

MARKAL-GPRA08 Model Results

Figure 3.18 shows the projected annual fuel consumption for light-duty vehicles, commercial light trucks, and heavy trucks in the Baseline Case and the Individual Program Case. The efficiency for advanced-technology vehicles is greater than the efficiency for conventional gasoline vehicles. As a consequence of the advanced-technology vehicles substitution for the conventional gasoline vehicles, fuel savings are 2.2 quads relative to the baseline in 2030. Commercial light-duty and heavy-duty truck efficiency improvements lead to an additional 1.1 quads of reduced oil consumption in 2030. Projected light-duty vehicle fuel savings in 2050 are 11 quads relative to the baseline, and commercial light and heavy truck savings are 2 quads relative to the baseline. Total fuel consumption savings associated with the Vehicles Program are 3 and 13 quads per year, respectively, in the midterm (2030) and long term (2050).



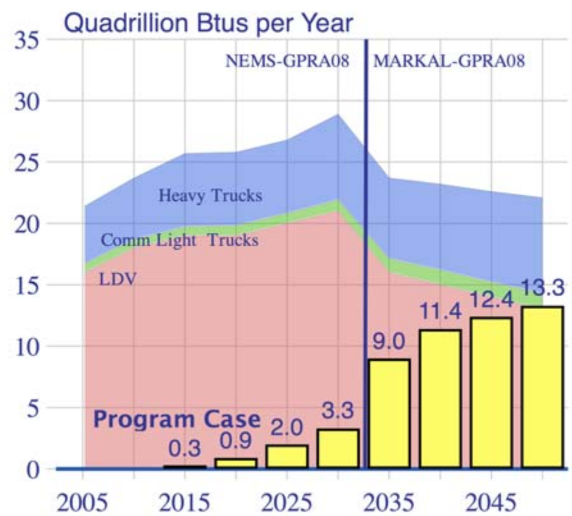


Figure 3.18. Fuel Consumption for the Baseline Case and the Vehicle Program Case

Yellow bars represent the savings in fuel consumption between the base and program cases

Table 3.13 summarizes the benefits of the Individual Program Case for the Vehicles Technologies Program. Among the economic benefits, the reduced fuel consumption in the transportation sector leads to significant consumer savings and energy system cost savings, as well as a reduced energy intensity of the economy. Cumulative consumer savings (reported as a net present value in 2008) are $260 billion and $1.6 trillion, respectively, by 2030 and 2050. Cumulative energy system cost savings—a proxy for consumer and producer surplus—is $81 billion. Energy intensity declines 3% and 10%, respectively, in 2030 and 2050. In the long term, the FCVT leads to increased costs to the electric sector, due to the high market penetration of plug-in hybrids.

Among the environmental benefits, reduced fuel consumption translates into avoided carbon emissions of 600 million and 5 billion metric tons of carbon equivalent, cumulatively, in 2030 and 2050 relative to the baseline. No significant effect is seen on pollution control costs—due to the fact that this metric applies only to the electric sector, and the fact that this program has little impact on electricity use in the midterm.

The FCVT program has the greatest impact on security benefits to the Nation, relative to all of the programs in EERE's portfolio. That is because almost all of the energy demand in the transportation sector is for petroleum. Oil imports are reduced by the FCVT program by 2 million and 6 million barrels per day in 2030 and 2050, relative to the Baseline Case. The improvement in "security MPG" is almost 4 miles per gallon of oil in 2030 and 64 miles per gallon of oil in 2050. Oil intensity of the economy is reduced by 7% and 28%, respectively, in 2030 and 2050. In addition to improving security by reducing fuel demand in the transportation sector, the Vehicles Program also improves transportation fuel diversity—by 8% and 24% in 2030 and 2050—as a result of increased use of electricity in plug-in hybrid vehicles.

In these integrated energy 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 energy 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. In addition, the "rebound" effect is 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 2030 is roughly 4% higher in the Individual Program Goal Case than in the Baseline Case. The rebound of gasoline consumption reduces the program savings. At the same time, consumer expenditure savings are greater. The small decreases in gasoline price apply to the total amount of fuel consumed and contribute significant additional expenditure savings. The net result of these lower fuel costs, combined with somewhat more expensive vehicles, yields consumer savings of $46 billion per year in 2030 or $255 billion on a cumulative net present value basis (evaluated at a 3% discount rate) from 2008 through 2030.

Table 3.13. FY08 Benefits for the FreedomCAR and Vehicle Technologies Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	ns	ns	ns	ns	ns	-1%	2%	1%	0%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	33	45	63	81
Consumer Savings, Annual (bil $2004)	ns	3	17	36	46	112	181	193	218
Consumer Savings, NPV (bil $2004) 2/	ns	10	49	139	255	702	1007	1332	1642
Electric Power Industry Savings, Annual (bil $2004) 3/	ns	ns	ns	ns	ns	-2	-2	-3	-10
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	ns	ns	ns	ns	ns	2	-1	-6	-16
Reduction in Fraction of Household Income Spent on Energy	ns	0%	1%	2%	3%	5%	6%	6%	7%
Reduced Energy Intensity of Economy (Percent)	0%	0%	1%	2%	3%	8%	9%	10%	10%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	1	6	22	45	69	172	220	224	210
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	3	22	90	275	580	1741	2744	3854	4932
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	ns	ns	ns	ns	ns	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	0.2	0.4	1.1	1.8	4	5	6	6
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	0.2	1	2	5	14	23	33	44
Security Fuel Economy Improvement (MPG)	0.1	0.5	1	2	4	13	21	29	46
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	4%	8%	12%	23%	25%	24%
Reduced Oil Intensity (Percent)	0%	1%	2%	5%	7%	19%	24%	26%	28%

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

Weatherization and Intergovernmental Program

The Weatherization and Intergovernmental Program (WIP) provides funding and technical assistance to its partners in state and local governments, Indian tribes, and international agencies to facilitate the adoption of renewable energy and energy efficiency technologies. WIP activities speed the adoption of new technologies and help transfer technologies that are developed by Department of Energy (DOE)-funded research to the private sector.

WIP activities are different from those of most DOE research and development programs that focus on basic science and hardware development. WIP projects are more likely to focus on issues such as economic development in rural areas or how renewable energy and energy efficiency projects can improve air quality. For this reason, it is difficult to characterize the benefits resulting from WIP activities by measuring their energy impact.

In general, WIP activities are characterized by:

- Multiple Technologies
  - WIP facilitates adoption of a range of technologies that are developed by the DOE Office of Energy Efficiency and Renewable Energy (EERE).
- Work across All Energy Market Sectors
  - WIP sponsors activities in the major energy market sectors—buildings, electric power, industry, and transportation—and works to educate the public, teachers, and students about the benefits of renewable energy and energy efficiency technologies. WIP also helps state and local agencies improve their energy efficiencies by upgrading public facilities.
- Partnerships
  - WIP is involved with a broad range of energy stakeholders that cover the breadth of the U.S. economy. WIP staff members consult regularly with the National Governors' Association, the National Association of State Energy Officials, the National Council of State Legislatures, the National Association of Counties, the U.S. Conference of Mayors, the National Association of State and Community Service Programs, and many others.
- Leverage of Federal Resources
  - Almost every WIP project involves substantial participation and investment by state and local agencies, Indian tribes, and the private sector.

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Translating WIP Goals and Program Outcomes into Energy Model Parameters

For FY2008, the State Energy Program (SEP) within WIP added three new grant areas to the analysis: Tax Credits, Procurement, and Renewable Energy. Additionally, SEP plans to revamp its Special Projects to focus on competitive grants that promote market transformation. In 2008, the State Energy Program will allocate approximately 78% of its funding to the traditional grant programs, and 22% of its funding to competitive grants. With a projected budget of $45 million, the traditional SEP grants will receive $35 million, and the new SEP Market Transformation program will receive $10 million. The SEP Special Projects: Competitive Grants program was developed to strategically realign the SEP program by transforming energy markets at the state level, to promote an integrated portfolio of energy efficiency and renewable energy options, and to strengthen the traditional state energy grant programs.

These new directions were introduced at the very end of the budget and benefits analysis process. As a result, at the time of the final FY 2008 budget submission to the Office of Management and Budget, only preliminary estimates of the benefits reflecting these changes were available for a limited set of metrics. In the meantime, a full set of benefits estimates have been done for the midterm only (through 2030). Projected annual energy savings for WIP are estimated offline, and provided directly as inputs to the integrated energy models.

Individual Program Case Results for Weatherization and Intergovernmental Program

Benefits of the Weatherization and Intergovernmental Program are summarized in **Table 3.14.** By 2030, cumulative carbon emission reductions are 138 MMTCE and the consumer savings are $62 billion on a net present value basis. Long-term benefits estimates were not done.

Table 3.14. FY08 Benefits for the Weatherization and Intergovernmental Program[9]

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	0.18%	0.31%	0.70%	1.11%	0.43%	nr	nr	nr	nr
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	nr	nr	nr	nr
Consumer Savings, Annual (bil $2004)	1.7	2.8	3.9	8.1	7.8	nr	nr	nr	nr
Consumer Savings, NPV (bil $2004) 2/	3.9	13	26	46	62	nr	nr	nr	nr
Electric Power Industry Savings, Annual (bil $2004) 3/	0.25	1.7	1.5	2.1	2.1	nr	nr	nr	nr
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	1.0	6.6	13	19	24	nr	nr	nr	nr
Reduction in Fraction of Household Income Spent on Energy	ns	ns	ns	ns	0.14%	nr	nr	nr	nr
Reduced Energy Intensity of Economy (Percent)	0.11%	0.26%	0.39%	0.35%	0.28%	nr	nr	nr	nr
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	1.8	4.5	9.7	8.3	6.6	nr	nr	nr	nr
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	4.0	22	57	101	138	nr	nr	nr	nr
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	0.49	1.1	0.89	3.6	3.2	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	ns	ns	ns	nr	nr	nr	nr
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	ns	ns	nr	nr	nr	nr
Security Fuel Economy Improvement (MPG)	ns	ns	ns	ns	ns	nr	nr	nr	nr
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	ns	ns	nr	nr	nr	nr
Reduced Oil Intensity (Percent)	ns	ns	ns	ns	ns	nr	nr	nr	nr

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error

[9] Last-minute changes in funding for WIP have resulted in changes to the benefits associated with this program. An erratum will be released later showing final results for benefits of WIP and will be available online.

Wind Technologies Program

The Wind Technologies Program is one component of the Wind and Hydropower Technologies Program under the Office of Energy Efficiency and Renewable Energy (EERE) within the U.S. Department of Energy. The Wind Program focuses on two key areas for its mission—increasing the Technical Viability of wind systems through support of research and development, and increasing wind energy deployment in the emerging marketplace through Technology Application activities. **Figure 3.19** depicts the five projects within the two key areas that comprise the Wind Program.

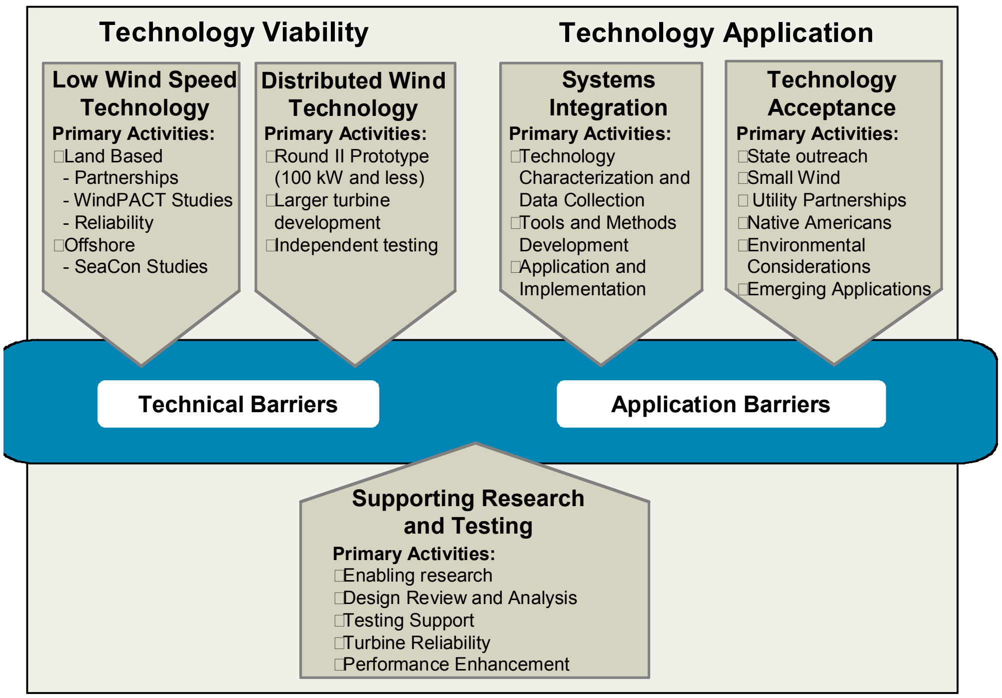

Figure 3.19. Structure of the Wind Program

For a detailed description of the Wind Technologies Program goals and activities, see the appendices to this report and the program's current multiyear technical plan.

Translating the Wind Technologies Program Goals into Energy Model Parameters

Analysts for the Wind Program have modified the *AEO2006* reference case to generate a Baseline (no DOE RD3 effort) Case, in addition to translating the program's goals and outputs into inputs to the integrated energy models (see the appendices for details.) The *AEO2006* projections show almost no improvement in cost or performance in future wind power technology from R&D. The program's Program Case projections for future wind plant capacity factors and capital costs both reflect larger improvements, compared to those in the *AEO2006*, i.e., capacity factors are higher and costs are lower.

To calculate the benefits from the DOE Wind Program, the GPRA 08 Baseline Case, unlike the *AEO2006* Reference Case, must reflect the absence of DOE-sponsored R&D. For the GPRA 08 Baseline Case, the *AEO2006* Reference Case capital cost is assumed for 2005 as the starting point. The 2005 capacity factor is the midpoint between the AEO2006 value and the program value, as in past GPRA analyses. To remove the impacts of Wind Program activities from the Program Case, a projected cost/performance trajectory was estimated whereby industry is assumed to achieve 60% of the COE reduction projected by the program at each five-year interval for all wind classes. This COE reduction level is supported by a preliminary analysis conducted by NREL staff that projected physical characteristics and performance levels of wind turbines likely to result if Federal research investment is discontinued. That analysis builds off of the extensive analysis underlying the Program Case. While the program focus is on low wind speed technology, much of the research is transferable to higher wind speed designs. Also, over the long term, industry is assumed to invest in higher wind-speed R&D, if needed. Therefore, as a first-order approximation, the 60% value is assumed for turbines designed for all wind power classes.

Figure 3.20 highlights a few examples of baseline and program case inputs. For class 4 winds, it compares the baseline assumptions used in this report with the assumptions currently used in the *AEO2006* reference case.

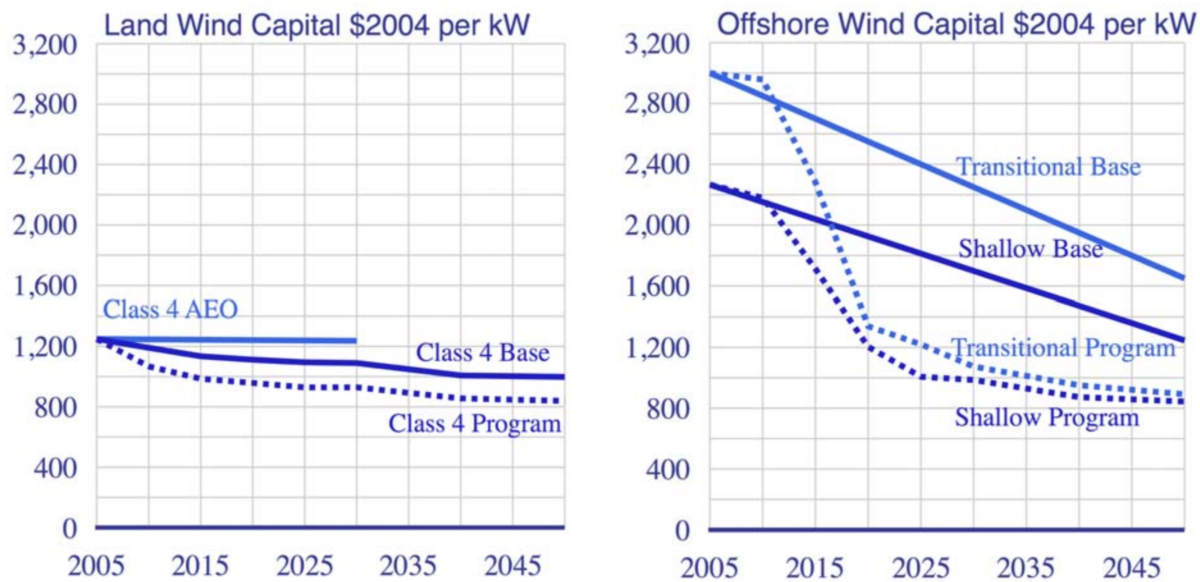

Figure 3.20. Comparison of Selected AEO2006 Reference, Baseline Case, and Program Case Assumptions

Individual Program Case Results for the Wind Technologies Program

The Wind Technologies Program seeks to reduce the cost—and improve the performance—of wind generation. The result is more cost-effective wind power and greater deployment. As shown in **Figure 3.21**, in the midterm, wind capacity in the Program Case is projected to be roughly twice that of the baseline as the result of the Wind Program's RD3 efforts. In 2030, land-based wind capacity increases from 50 GW in the Baseline to 90 GW in the Individual Program Goal Case, relative to the Baseline Case. Offshore wind shows little growth in the baseline without R&D, and increases to more than 10 GW in 2030 as its costs and performance improves. Incremental wind capacity associated with the Wind Program is 52 GW in 2030. In the long term, land-based wind capacity levels off in 2035 at 127 GW (2.5 times greater than the baseline). Offshore wind capacity reaches almost 120 GW by 2050, bringing the total wind capacity in the Program Case to more than 240 GW—almost five times greater than the Baseline Case. Incremental wind capacity associated with the Wind Program is more than 190 GW in 2050.

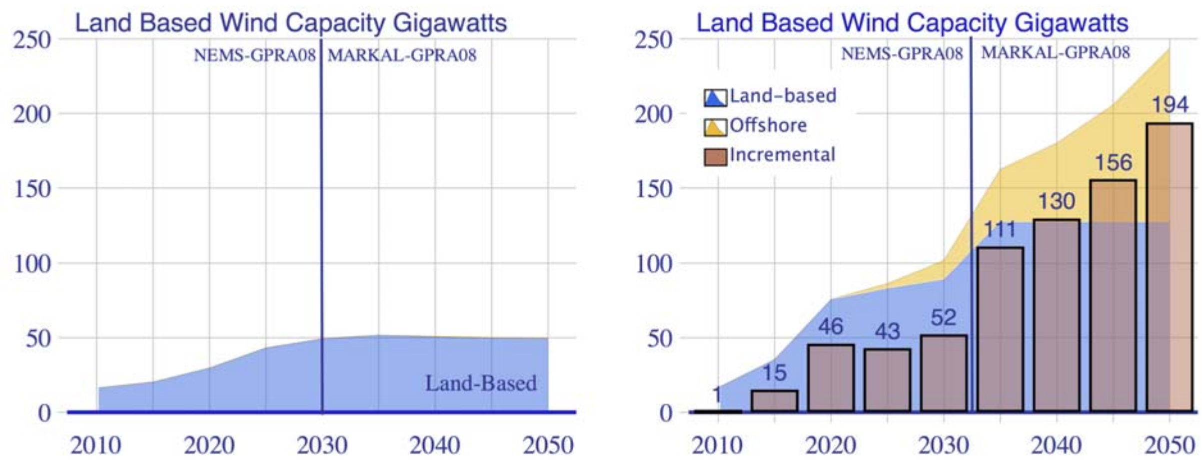

Figure 3.21. Projected Wind Capacity for the Base Case and the Wind Program Case

Table 3.15 provides estimates of the economic and environmental benefits stemming from wind energy displacing fossil-fueled generation sources. Because very little oil is used in power generation, the wind program has little impact on oil-based security benefit metrics. 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 by a cumulative total of $61 billion by 2030 and $150 billion by 2050. Similarly, cumulative electricity system cost savings are $31 billion in 2030 and $107 billion in 2050. Energy system cost savings reach $6 billion in 2050. Carbon emissions reductions total 36 MMTCE in 2030 or almost 460 MMTCE cumulatively from 2008 to 2030. By 2050, annual carbon emission reductions reach 140 MMTCE or almost 3 billion MTCE cumulatively from 2008 to 2050.

Table 3.15. FY08 Benefits for the Wind Program

	MIDTERM BENEFITS 7/					LONG-TERM BENEFITS 8/			
Metric	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMIC BENEFITS ("AFFORDABLE")									
Reduction in Average Delivered Natural Gas Price (Percent)	ns	ns	2%	ns	ns	2%	2%	1%	0%
Energy System Cost Savings (bil $2004) 1/	nr	nr	nr	nr	nr	2	3	5	6
Consumer Savings, Annual (bil $2004)	ns	2	9	6	8	12	12	5	-4
Consumer Savings, NPV (bil $2004) 2/	ns	5	26	49	61	112	136	150	150
Electric Power Industry Savings, Annual (bil $2004) 3/	0	1	4	2	3	11	9	5	3
Electric Power Industry Savings, NPV (bil $2004) 2/ 3/	0	4	14	24	31	71	90	101	107
Reduction in Fraction of Household Income Spent on Energy	ns	ns	ns	ns	ns	0%	0%	0%	0%
Reduced Energy Intensity of Economy (Percent)	0%	0%	1%	1%	1%	2%	2%	2%	2%
ENVIRONMENTAL BENEFITS ("CLEAN")									
Avoided Greenhouse Gas Emissions, Annual (MMTCE/year)	1	10	30	31	36	104	113	121	139
Avoided Greenhouse Gas Emissions, Cumulative (MMTCE) 5/	2	33	139	286	457	1083	1631	2218	2877
Reduced Cost of Criteria Pollutant Control, NPV (bil $2004) 2/	0	1	2	4	5	nr	nr	nr	nr
SECURITY BENEFITS ("RELIABLE")									
Avoided Oil Imports, Annual (mbpd)	ns	ns	ns	ns	ns	0	0	0	0
Avoided Oil imports, Cumulative (bil barrels) 4/ 5/	ns	ns	ns	ns	ns	0	0	0	0
Security Fuel Economy Improvement (MPG)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Transportation Fuel Diversity Improvement (percent) 6/	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table notes:

1/ Energy system costs include the annualized capital costs for all capital stock (residual and new), as well as O&M and fuel costs. Annualized capital costs are calculated using MARKAL hurdle rates, which include both a financial and behavioral component.
2/ NPV (net present value) calculations done using 3% real discount rate back to 2008.
3/ Electric power industry cost does not include demand-side distributed generation.
4/ Renewable generation values at output value (3412 Btu/kWh), except for biomass where energy content is used.
5/ All cumulative values are from 2008.
6/ Diversity index change is Case minus Base (opposite of others).
7/ Midterm benefits based on NEMS-GPRA08 model.
8/ Long-term benefits based on MARKAL-GPRA08 model.
nr = not reported or calculated by model
ns = not significant relative to model error