CHAPTER 2

EERE BENEFITS-ANALYSIS PROCESS

The Office of Energy Efficiency and Renewable Energy's (EERE) benefits-analysis process involves three major steps (**Figure 2.1**). In **Step 1,** EERE's Office of Planning, Budget, and Analysis (PBA) develops a standard baseline and methodological approach (guidance) to help ensure consistency in estimates across programs. In **Step 2,** EERE's programs develop specific technology and market information, which is necessary to understanding the potential roles of each program in its target markets. In **Step 3**, PBA uses this program and market information to assess the impacts of each EERE program (as well as the overall EERE portfolio) on energy markets in the United States using integrated energy-economic models.

STEP 1 – Baseline Case and Guidance

- Create a Baseline Case without EERE RDD&D.
- Make any necessary updates to EERE's guidelines on estimating benefits.

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STEP 2 – Program and Market Inputs

- Review the baseline projections of the timing and rate of adoption of EERE technologies.
- Assess the potential roles of each program's performance goals in these future energy markets.
- Develop inputs to Step 3.

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STEP 3 – Program and Portfolio Benefits Estimates

- Develop estimates of individual program benefits (the Program Case).
- Develop estimates of the combined benefits of all programs (the Portfolio Case).

Figure 2.1. EERE Program and Portfolio Benefits-Analysis Process

Step 1: Baseline Case and Guidance

Baseline Case

The EERE Baseline Case is a projection intended to represent a possible future U.S. energy system without the effect of EERE programs. This Baseline Case is intended to serve four purposes: First, it assures that each program's benefits are estimated using the same initial forecasts for economic growth, energy prices, and levels of energy demand. Second, it assures that these initial assumptions are consistent with each other; *e.g.*, that the level of electricity demand expected could be met at the electricity price assumed. Third, it provides a basis for assessing how well renewable and efficiency technologies might be able to compete against future, rather than current, conventional energy technologies (*e.g.*, more efficient central power generation). Fourth, it helps ensure that underlying improvements in efficiency and renewable energy are not counted as part of the benefits of the EERE programs.

EERE used the Energy Information Administration (EIA) *Annual Energy Outlook 2003* (*AEO2003*) Reference Case as the starting point for developing the Baseline Case.[1] The *AEO2003* Reference Case provides an independent representation of the evolution of energy markets. This forecast reflects expected changes in the demand for energy, technology improvements that might improve the efficiency of energy use, and changes in energy-resource production costs, including renewable energy. The *AEO2003* Reference Case also includes current energy policies (*e.g.*, state renewable portfolio standards) that facilitate the development and adoption of these technologies. These policies are kept in the Baseline Case to ensure that EERE's benefits estimates do not include the expected impacts of such policies.

In establishing its Baseline Case, EERE makes a number of modifications to the *AEO2003* Reference Case (**Table 2.1**). The modifications include removing discernable representations of EERE programs, updating policy and market factors where additional information is available, and improving the structural representation of markets important to EERE technologies. While described here for the Baseline Case, some of these changes affect the Program and Portfolio Cases as well.

Modifications are made to the same model—the National Energy Modeling System (NEMS)—used by EIA in developing the *AEO2003*. To distinguish it from EIA's version, the model is referred to as NEMS-GPRA05. The *AEO2003* Reference Case is also the starting point for the long-term (to 2050) benefits modeling using MARKAL-GPRA05. The Baseline Cases for both NEMS-GPRA05 and MARKAL-GPRA05 are aligned as closely as possible, because the two models are different in their internal design.[2]

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[1] *The Annual Energy Outlook 2003 with Projections to 2025*, January 2003, DOE/EIA-0383 (2003). See http://www.eia.doe.gov/oiaf/archive/aeo03/pdf/0383(2003).pdf. EERE is codeveloping, with the Office of Fossil Energy, scenarios to reflect several potential energy futures, pursuant to a recommendation by the National Research Council to reflect market uncertainties (referred to as "option value") and suggestions made in a follow-up conference on ways to represent market uncertainties in benefits analysis. Scenarios will include differences in policy, as well as potential differences in energy markets.

[2] See Box 4.1 in Chapter 4 for an overview of NEMS and Box 5.1 in Chapter 5 for an overview of MARKAL. General information on energy-economy modeling is contained in last year's report, *Projected Benefits of Federal Energy Efficiency and Renewable Energy Programs FY2004 – FY 2020* (April 2004), available at http://www.eere.energy.gov/office_eere/gpra_estimates_fy04.html.

Table 2.1. Summary of Baseline Changes from the AEO2003

	AEO2003	GPRA Baseline Case
Removal of EERE Programs		
Million Solar Roofs	0.4 GW installed 2004 to 2025	Removed
Hydroelectric capacity	Roughly constant hydro capacity and generation	6% reduction by 2025
Cellulosic ethanol production	0.6 billion gallons by 2025	0.15 billion gallons by 2025
DG technology improvement	Significant improvement	Some improvement but less
Distributed peak-load technology	5% fixed capacity factor	2.5% fixed capacity factor, Reciprocating engines added
Energy Market Updates		
PV system size	2 kW residential, 10 kW commercial	4 kW residential, 100 kW commercial
PV maximum market share	30% for both residential and commercial	60% for residential and 55% for commercial
CHP commercial building maximum share	30%	50%
California PV subsidy	Not included	Included for residential systems
Solar water heat	New homes not represented, Maximum 20% of replacement market	New homes represented, Maximum 50% of replacement market
Cellulosic conversion efficiency	90 to 103 gallons of ethanol per dry ton of biomass	82 to 101 gallons of ethanol per dry ton of biomass
Structural Changes		
Wind module	One capital cost and resource multiplier for all wind classes	Capital costs and resource multipliers for each wind class
Commercial shell efficiency	Index	Technology representation
Commercial DG algorithms		Market share and stock accounting modified

Removal of EERE programs. EIA includes some of the impacts of EERE's programs in its Reference Case. In developing the Baseline Case, EERE removes these representations so that they can be analyzed in the Program and Portfolio Cases. For example, EERE removed EIA's estimate of rooftop photovoltaic installations resulting from the Million Solar Roofs Initiative from the EERE Baseline Case. EERE also modified the *AEO2003* assumption of roughly constant hydroelectric capacity over time to reflect the expectation that without more environmentally benign turbine designs, some reduction in hydroelectric capacity would occur as a result of relicensing requirements.[3] The *AEO2003* constrains the maximum growth rate for cellulosic ethanol production. EERE further constrained this growth rate by a factor of 4 in the Baseline Case to reflect the absence of EERE program involvement.

The *AEO2003* forecast includes technology improvements in all areas of energy demand and supply. Identifying what portion of these improvements is due to EERE programs is extremely difficult. For the Baseline Case, EERE modified technology improvements where the *AEO2003* appeared to already incorporate EERE program goals. Technology characteristics that were modified for the Baseline Case include cost and efficiency improvements of distributed combined heat and power (CHP) technologies that were reduced to reflect expected effects without an ongoing Distributed Energy Resources (DER) Program. In addition to CHP in the buildings and industrial sectors, NEMS characterizes two distributed generation (DG)

[3] See the Hydropower Program documentation provided in Appendix L for a description of hydropower capacity expectations.

technologies within the electricity sector that are options to reduce transmission and distribution expenses through strategic location of generators. One of these is defined as a base-load technology and the other as a peaking technology. The analysts modified the latter to represent reciprocating engines (lower capital costs and lower efficiency), and the fixed capacity factor was reduced from 5 percent to 2.5 percent.

Energy Market Updates. The analysts made a few other modifications to reflect updated information about energy markets. The size of typical photovoltaic (PV) systems was increased from 2 kW to 4 kW in residential building and from 10 kW to 100 kW in commercial buildings to reflect recent PV installation experience and trends. The maximum market for PV systems was increased from 30 percent to 55 percent in the commercial sector and to 60 percent for residential PVs. Similarly, analysts increased the maximum market share for gas-fired distributed generation technologies from 30 percent to 50 percent in the commercial sector. California PV credits were incorporated in the Pacific region. Analysts added solar water heat to the slate of technologies for new homes, and increased the share of the replacement market in which it can compete from 20 percent to 50 percent. The conversion efficiency of cellulosic ethanol was updated to reflect technical targets that are more recent than those used by EIA.[4] These changes allow the models to make greater use of these technologies in the future than would be allowed under the *AEO2003* Reference Case, based on observed changes in the energy market.

Structural Changes. In a few cases, analysts made structural changes to improve the model's representation of markets important to EERE technologies. The wind module was modified so that each of the three wind classes is treated more discretely with separate capital costs and resource multipliers. These regional wind-resource cost multipliers increase capital costs as increasing portions of a wind class are developed in a given region to reflect (1) declining natural resource quality, (2) required transmission network upgrades, and (3) competition with other market uses, including aesthetic or environmental concerns.[5] The shell indices in the commercial module were replaced with a technology choice algorithm necessary for representation of EERE shell technologies. In addition, analysts made alterations to the distributed generation algorithm in the building modules to smooth[6] new market shares, to reflect market adoption data gathered by the DER Program[7], to account for the efficiency of using waste heat from combined heat and power systems, and to account for buildings that have already installed a DG technology.

The adjustments to the *AEO2003* Reference Case result in an insignificant difference in energy consumption. For example, nonrenewable energy demand in the *AEO2003* Reference Case is 130.3 quadrillion Btu (quads) in 2025. The EERE Baseline Case value for 2025 is 130.1 quads, a difference of 0.2 quads or 0.15 percent. The closely aligned Reference and Baseline Cases contain considerable technological improvement. The extent of this technological improvement

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[4] The conversion efficiencies in the *AEO2003* are vintage 1998. These were updated based on modeling runs by NREL's biofuels analytic group. See National Renewable Energy Laboratory, Kelly Ibsen memorandum to Tien Nguyen, DOE, on NREL Reported Biomass-to-Ethanol Cases, 1999-2001.

[5] In the *AEO2003* version of NEMS, these multipliers are applied to the entire wind resource in each region; whereas, in NEMS-GPRA05, they are applied separately by wind class. This latter treatment tends to be more restrictive because cost increases due to resource depletion occur more quickly for the best wind class.

[6] An algorithm based on integer values (payback in years) was replaced with a continuous functional form.

[7] *Market Trends in the U.S. ESCO Industry: Results from the NAESCO Database Project*. Goldman, C., J. Osborn and N. Hopper, LBNL, and T. Singer, NAESCO, May 2002, LBNL-49601.

is partly reflected in the declining energy intensity during the forecast period. While nonrenewable energy demand in the Baseline Case increases by 35 percent from 2005 to 2025 (to 130 quads) and by 56 percent from 2005 to 2050 (to 150 quads), underlying energy efficiency and renewable energy improvements contribute toward a 26 percent reduction in nonrenewable energy intensity (nonrenewable energy used per dollar of GDP produced) by 2025 and a 49 percent reduction by 2050 (**Figure 2.2**) .[8] The impact of the improved intensities is substantial. If nonrenewable energy intensity were to remain constant at 2005 levels, then nonrenewable energy demand would be 35 percent higher in 2025 and 97 percent higher in 2050 than it is under the Baseline Case.

Improvements in renewable energy technologies are also contained in the Baseline Case. Between 2005 and 2025, renewable energy technology improvements result in increases in electric generation (in billions of kWh) of 27 for geothermal, 28 for biomass, 7 for wind, 4 for municipal solid waste, 19 for photovoltaics, and 0.3 for solar-thermal.

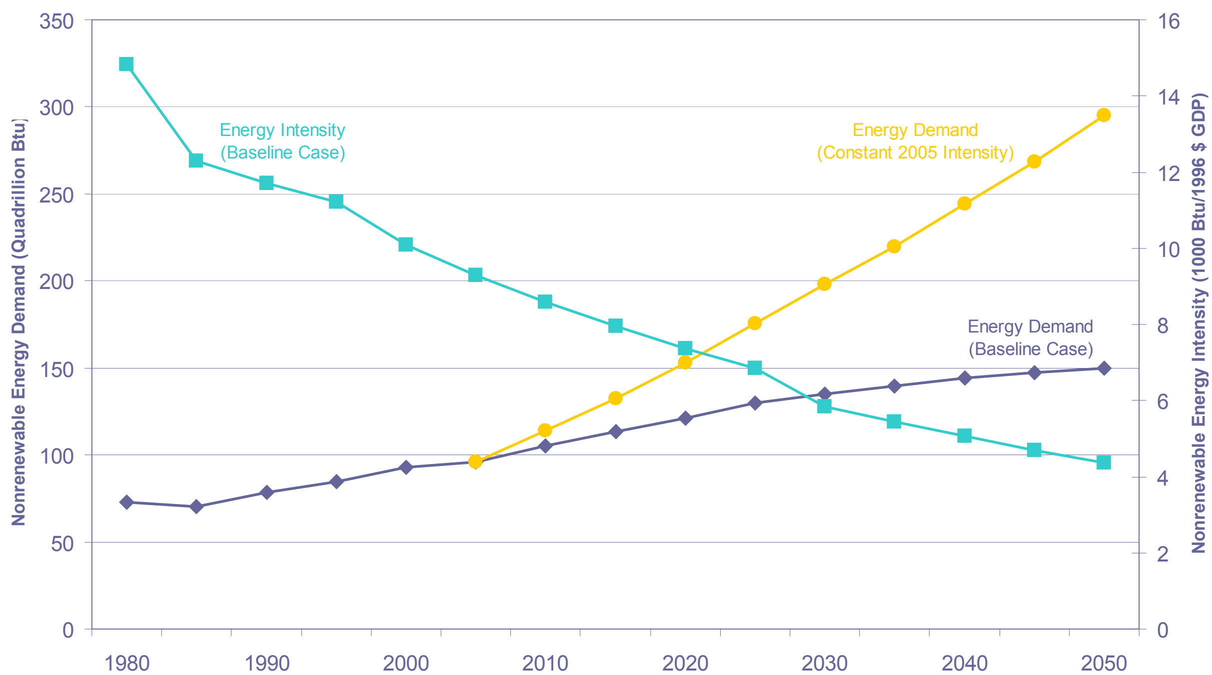

Figure 2.2. U.S. Nonrenewable Energy Demand and Energy Intensity, 1980-2000, and Baseline Projections to 2050

Data Sources: 1980-2000, Energy Information Administration, *Annual Energy Review 2002*, DOE/EIA-0384 (2002) (Washington, D.C., October 2003), Tables 1.3, E1 Web site http://www.eia.doe.gov/emeu/aer/contents.html; 2005-2025, NEMS-GPRA05; 2030-2050, MARKAL-GPRA05.

EERE benefits estimates do not include any of these efficiency or renewable Baseline Case improvements. Rather, the R&D improvements represented in the Baseline Case provide the

[8] Energy-intensity changes result from a mix of structural changes in the economy (*e.g.*, growing service sector) and efficiency improvements. Two recent EERE-sponsored studies provide additional background on understanding the sources of changes to our energy intensity: Ortiz and Sollinger, *Shaping Our Future by Reducing Energy Intensity in the U.S. Economy; Volume 1: Proceedings of the Conference* (2003, Rand Corporation); and Bernstein, Fonkych, Loeb, and Loughran, "State-Level Changes in Energy Intensity and their National Implications," (2003, Rand Corporation).

"next best technologies" against which additional EERE improvements are compared. More detail from EERE Baseline Case projections is in **Appendix A**.

Guidance

In order to improve the consistency of estimates across EERE's portfolio, EERE utilizes common methodological approaches, definitions, and conversion factors. Prior to the reorganization, EERE utilized these common elements in the form of an annual "GPRA Data Call"[9] to the five EERE Sectors, which undertook separate analyses based on these common guidelines. With the reorganization, the benefits-analysis team utilizes this methodology directly, including:

Definitions. Common definitions for benefits metrics and related terms are provided.

Converting nominal dollars to real dollars. The results of EERE's benefits analysis are reported in constant ("real") dollars as opposed to current/future year ("nominal") dollars to compensate for the effects of inflation over time. In cases where the program or other sources provide future expenditures or costs in nominal dollars, these are converted to constant dollars based on a forecasted GDP deflator.

Next best technology. The benefits of EERE technologies are assessed compared to the best technologies expected to be available to the market at the time the EERE technologies are developed—not compared to the technologies available or installed today. The Baseline Case provides the future "next best technologies" against which EERE technologies will compete. In markets where the models do not have explicit technology representation, the "next best technology" is reflected in the Baseline Case rates of technology and market improvements. In most cases, EERE R&D efforts accelerate the development and introduction of these technologies, while its deployment efforts principally accelerate the market penetration of technologies once they have reached the market.[10] In specific cases, the RD&D efforts also may be directed toward changing the attributes of technologies in the market (*e.g.*, less polluting) or of developing technologies that are not reflected in the Baseline Case within the timeline of analysis. (See **Box 2.1—Impact of EERE Programs**).

Market characteristics and penetration rates. It takes time for new products to reach their full market potential, and these market-penetration rates vary considerably by technology and market. The Baseline Case includes assumptions about technology-adoption rates for many markets, primarily through the use of consumer "hurdle rates" or other representations of the

[9] The guidance used for FY 2005 benefits estimates followed the guidance for FY 2003 (see http://www.eere.energy.gov/office_eere/ba/gpra_estimates_fy03.html). EERE will continue to maintain standard assumptions and methodologies for estimating program benefits.

[10] This is a starting assumption. There may be cases in which EERE's efforts principally change the characteristics of the technologies being marketed (*e.g.*, less polluting) rather than, or in addition to, accelerating market introduction and penetration. At times, EERE may be developing technologies that are not expected to be developed by the private sector (*i.e.*, they do not show up in the Baseline Case at all). Finally, some research efforts include built-in deployment components that may result in a combined accelerated introduction and accelerated penetration effect. These variations on the basic approach described above are addressed in the program-level appendices to this report.

trade-off between upfront investment costs and annual operating costs (including energy expenses) over time, as well as other attributes in selected cases. Where technologies are not explicitly represented, adoption rates are embedded in efficiency trends. Efficiency trends may implicitly include capital stock turnover, as well as technology efficiencies and rate of uptake of different technologies. Other market characteristics (such as regional markets, regulatory constraints, or typical start-up time for new product lines) can influence adoption rates and also may be specifically represented in the Baseline Case. For R&D activities, the market characteristics and factors affecting adoption rates remain the same for the Program Case and the Baseline Case, unless the new technology would fundamentally change the way the target markets operate (*e.g.*, accelerate stock turnover or increase consumer acceptance of new technologies). For deployment activities, the program output goals provide a basis for assessing the expected acceleration of market-penetration rates (or other changes in market characteristics), due to the program activities in the Program Case.

Technology performance and cost. For R&D programs, the benefits analysis is based on the performance and cost of the technologies being developed or deployed. For each technology (or class of technologies), key technology characteristics include:

- Expected year of technology availability
- Capital costs
- Operations and maintenance (O&M) costs
- Technology product lifetime
- Technology performance and/or energy displaced/unit by fuel type
- Other technology features that might affect market acceptance

Two sets of technology characteristics are of interest: Baseline Case and Program Case. The EERE Baseline Case already includes expected private-sector advances in efficiency and renewable technologies. In many cases, the specific technology characteristics are included directly in the NEMS-GPRA05 and MARKAL-GPRA05; while, in other cases, they are represented through overall rates of technology improvement—and the characteristics for specific technologies must be inferred from these rates. For R&D efforts, the Program Case technology characteristics and costs generally reflect the program output goals. For deployment efforts, the technology characteristics remain the same in the Baseline and Program Cases.

Calculating direct energy and primary energy displaced. NEMS-GPRA05 and MARKAL-GPRA05 provide projections of direct (site) energy savings from end-use programs and the corresponding primary energy reductions. Reduced electricity demand leads to reduced generation and fuel consumption by electric power producers. The amount of fuel consumed (and saved) changes as the marginal efficiency of power production increases with the increased efficiency of conventional, central power production. When the principal market analysis is performed off-line, the resultant energy savings (expressed in direct energy terms) are used as an input to the NEMS-GPRA05 and MARKAL-GPRA05 models. The two models then compute primary energy savings based on the direct energy savings.

Box 2.1—Impact of EERE Programs

For EERE R&D efforts, the initial assumption is that the impact of the program is to accelerate the commercial introduction of a technology (see **Figure 2.3a**). In some cases, that may be the only effect. In other cases, the EERE R&D effort may develop a technology with features that can affect the ultimate size of the market, or that otherwise would not have been developed by the private sector.* For EERE deployment efforts, the initial assumption is that the impact of the program is to accelerate the rate of adoption of a technology already developed and introduced to the market (see **Figure 2.3b**). In some cases, the EERE deployment effort also may impact the total size of the market, in addition to the rate of adoption. In such cases, the program affects the maximum market share the technology achieves.

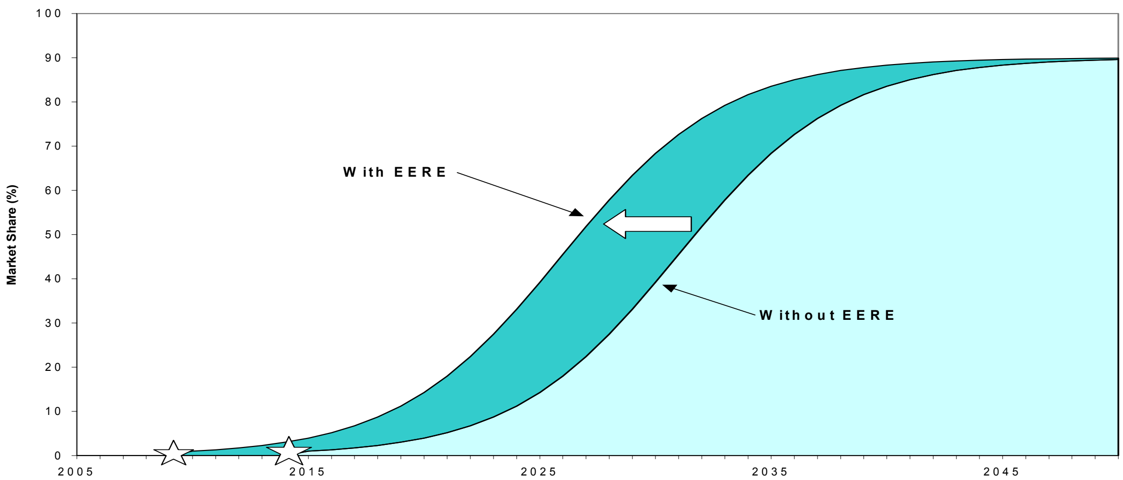

Figure 2.3a. Potential Impacts of EERE R&D Programs on Technology Introduction

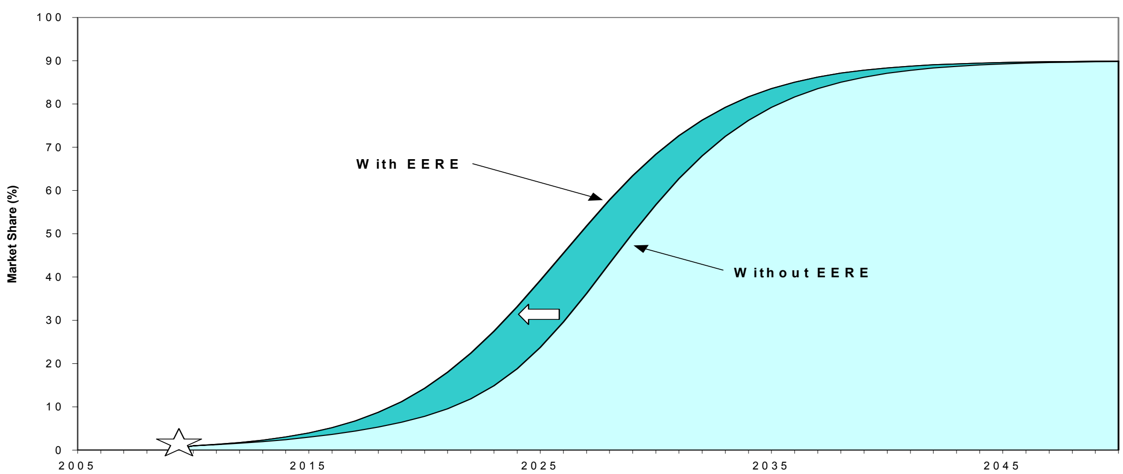

Figure 2.3b. Potential Impacts of EERE Deployment Programs on Market Penetration

*Assuming the technology, or technological characteristic, would have been developed by the private sector anyway. In some cases, technologies are so far from potential commercialization—or so risky—that private-sector firms do not invest in them. In others, the private sector lacks the market incentive to develop technology features, such as improved load-balancing for home appliances (which could improve the reliability of the electricity grid), because the markets do not provide the price signals that would generate profits from these public benefits.

Calculating carbon equivalent emissions reductions. NEMS-GPRA05 and MARKAL-GPRA05 compute carbon emission reductions based on the amount of coal, oil, and natural gas consumed in the Baseline, Program, and Portfolio Cases, as well as the carbon coefficients of each energy source. Carbon emissions are computed using NEMS-GPRA05 and MARKAL-GPRA05. The carbon emissions associated with the displacement of fossil-generated electricity by efficiency or renewable technologies will vary over time and reflect the increasing efficiency of new fossil generators and the dynamic shift in fuel sources.

EERE's ability to apply these methodological approaches varies considerably by program, depending on the availability and cost of market data, the ability to assess public and private-sector technology contributions, and the capability to reflect specific market conditions in energy models available to EERE.

Step 2: Program and Market Inputs

In **Step 2**, program goals and salient target market characteristics are developed as inputs to modeling the benefits estimation in **Step 3**. The effort required under **Step 2** varies considerably, depending on the form in which programs specify their output or performance goals and how NEMS-GPRA05 and MARKAL-GPRA05 utilize this information. It ranges from the compilation of technology goals to detailed market analyses that produce technology penetration rates—and, in some cases, delivered energy savings.

NEMS-GPRA05 and MARKAL-GPRA05 contain detailed technology representations of electricity markets, most residential and commercial end uses, and vehicle choice—but use trends for the representation of industrial efficiency improvements and existing residential shell retrofits. For programs that address these markets, this step simply requires (1) confirming the adequacy of the target market representation in the Baseline Case and (2) providing the program goals in a format consistent with the model. Any updated market characteristic information is used to adjust NEMS-GPRA05 and MARKAL-GPRA05 for both the Baseline Case and the Program Case to avoid ascribing external factors as benefits. Analysts use the program goal information to adjust the commercialization date, technology characteristics, or market penetration rate for the Program Case. The comparison of market technology introduction and market penetration rates, with and without the program goal—and the calculation of the energy displaced—occur within NEMS-GPRA05 and MARKAL-GPRA05.

For much of EERE's portfolio, additional "off-line" analyses are needed to translate information about program technology and market characteristics into usable modeling inputs. This off-line **Step 2** analysis can range from spreadsheet calculations to the use of market-specific models to assess technology or market features that cannot be adequately represented in a broad energy-economic model, or to translate program goals into the variables used in the modeling. In general, analysts perform the most detailed off-line analyses for the Industrial Technologies Program, Weatherization and Intergovernmental Program (WIP), Federal Energy Management Program (FEMP), and portions of the Building Technologies Program. Analysts tailor these off-line analytical approaches to the characteristics of the program and target market being analyzed; but, in any case, they are conducted within the overall guidance provided through the GPRA benefits estimation process.

The market applications for EERE technologies are often very specific, and resulting energy savings for a given technology can vary significantly from one application to another. For example, the impact of upgrading building codes can vary significantly (due to differences in climate and in existing building-code standards) and therefore require analysis at the State level. The Building, Industrial, and WIP programs are most likely to require tailored analytical approaches that address these submarkets.

Where NEMS-GPRA05 and MARKAL-GPRA05 do not include technology-by-technology information (*e.g.*, cost, date of availability), or specific market-penetration rates, it is often necessary to translate program goals into the more general rates of technology improvement used by the models. This is true for the Industrial Technologies Program and some elements of the Building Technologies Program, where numerous specific technology advances or market deployment efforts will accelerate overall efficiency improvements in buildings or factories specified in the Baseline Case.

Off-line analysis also can be required for targeted submarkets that are simply not included in NEMS-GPRA05 or MARKAL-GPRA05—or for which the resulting technology use is not fully market-driven. Examples include the Federal sector (addressed by FEMP) and the Low-Income Weatherization Assistance Program, in which the Federal Government directly purchases home efficiency improvements.

Finally, supporting "off-line" analysis can be required where market functions are not well represented in a full energy-economic model. For example, consumer willingness to pay a premium for electricity produced by environmentally friendly technologies is not represented within the electricity market in NEMS-GPRA05 and MARKAL-GPRA05; and, therefore, another model specifically designed to analyze this market provides the input assumptions on this market segment. Also, programs designed to help overcome institutional barriers to efficiency adoption are often difficult to represent in market-based models.

Because estimating the benefits of achieving program performance goals requires the ability to realistically assess the extent to which future energy markets might adopt the technology and market improvements developed by EERE programs, analysts explore the following features in these off-line analyses:

Target Markets. New technologies will not necessarily be well suited to all applications served by existing markets. Technologies may occupy niche markets, especially in early years. In some cases, initial markets are geographically limited as well. Where integrated models do not represent these submarkets explicitly, it may be necessary to develop off-line estimates of the applicable market share for the technology being developed, at least in the early years.

Stock Turnover. Modeling stock turnover is crucial to estimating benefits for both new technologies and deployment programs. Analyses of the market adoption of new technologies must consider the rate at which the specific type of energy-using or -producing capital equipment is replaced, in addition to the growth rate of the overall market. Even when a technology is suitable and cost-effective for a percentage of a market, it may take a decade or more for the capital stock in that portion of the market to retire and be replaced. Particularly attractive new technologies might accelerate that turnover. EERE includes this potential for early retirement only when market evidence suggests that the technology improvement is significant enough to overcome typical hurdle rates to new investment. Although stock turnover fluctuates with business cycles, EERE does not incorporate business cycles into its Baseline or Program cases. As a result, nearer-term estimates of benefits, in particular, do not take into account year-to-year fluctuations in energy use attributable to business cycles.

Next Best Technology. Where technology representation is implicit (in a technology improvement index, for instance), the Baseline Case improvement must be translated into improvement rates for a specific set of technologies. Analysts use this set of baseline technologies to assess the specific markets in which the EERE technology might be competitive in different time frames.

Market Penetration. Over time, new technologies typically make their way into markets—and, therefore, affect energy use—gaining their share of new sales as consumers learn about the availability of the product. Manufacturing capacity then grows, and product prices fall with economies of scale and learning.[11] While price helps determine whether a product is cost-effective, on average, energy prices vary by type of customer and region, so that new products may be cost-effective for some customers (a niche market) before they are generally cost-effective. Price, or cost-effectiveness, is often not the only aspect of the new technology or deployment program that shapes its rate of market uptake. Many non-price or cost factors affect consumer behavior.

As an example, the off-line analysis for the Industrial Technologies Program uses a spreadsheet model that provides several possible market penetration curves. The analyst chooses a curve, based on specific information from possible R&D partners, comparison of the new technology to similar technologies, or his or her expert judgment. The benefits guidance for industrial benefits estimation includes historic penetration curves for 11 technologies and offers the analyst five choices of penetration curve shapes. The five choices are accompanied by detailed data on technology equipment, financial, industry, regulatory, and impact characteristics to aid in making the choice. In addition to choosing the shape or the penetration curve, the analyst chooses the year—after all pilot testing and demonstration phases—the new technology is expected to enter the market.

Through the use of specialized spreadsheets or other models,[12] program analysts produce estimates of market penetration and direct energy savings associated with these market sales. However, these "off-line" estimates of direct energy savings are not benefits estimates because they do not account for market interactions. Analysts integrate these off-line estimates within the NEMS-GPRA05 and MARKAL-GPRA05 models as the final part (**Step 3**) of the process.

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[11] See Adam B. Jaffe, Richard G. Newell, and Robert N. Stavins, "Energy-Efficient Technologies and Climate Change Policies: Issues and Evidence," Climate Issue Brief No. 19, *Resources for the Future*, Washington, D.C. (December 1999).

[12] In one case (the Building Technologies Program), a portion of NEMS (the buildings module) was used for off-line analysis.

Step 3: Program and Portfolio Benefits Estimates

The final step for estimating the impacts of EERE's FY 2005 Budget Request is to analyze all EERE's programs in a consistent economic framework and to account for the interactive effects among the various programs. Estimates of individual EERE program energy savings cannot be simply summed to create a value for all of EERE, because there are feedback and interactive effects resulting from (1) changes in energy prices resulting from lower energy consumption and (2) the interaction among programs affecting the mix of generation sources and those affecting the demand for electricity.

The process begins by analysts modeling each EERE program individually within NEMS-GPRA05 and MARKAL-GPRA05 to the extent possible. In each NEMS-GPRA05 and MARKAL-GPRA05 Program Case, only the modeling assumptions related to the outputs of the program being analyzed are changed. The modeling assumptions related to the other EERE programs remain as they were in the EERE Baseline Case. Analysts model each program separately to derive estimated energy savings without the interaction of the other programs. They then compare the results from the NEMS-GPRA05 and MARKAL-GPRA05 Program Cases to the Baseline Case to measure the individual benefits of the EERE program being analyzed.

For programs modeled using NEMS-GPRA05 and MARKAL-GPRA05 directly, analysts compute the Program Case by changing the assumptions representing the program outputs; *i.e.*, the goals or performance targets of the program, such as reducing low wind-speed turbine costs and improving their performance. The R&D programs are represented in NEMS-GPRA05 and MARKAL-GPRA05 through changes in technology characteristics that represent the program goals, to the extent possible. Activities designed to stimulate additional market penetration of existing technologies generally were modeled through changes in consumer hurdle rates or other appropriate market-penetration parameters, with the goal of representing the market share targeted by the program.

In cases where program goals cannot be easily modeled using NEMS-GPRA05 and MARKAL-GPRA05, analysts estimate benefits using a variety of off-line tools, as described in **Step 2**. These supporting analyses typically provide either estimates of market penetration and per-unit energy savings, or total site energy savings that are then used as inputs to NEMS-GPRA05 and MARKAL-GPRA05. In cases where the off-line analyses produce a direct estimate of site energy savings, analysts adjust this information by an "integration factor" and incorporate it in NEMS-GPRA05 and MARKAL-GPRA05 in order to calculate primary energy savings. The amount of the integration factor is based on how much program overlap or "integration" was captured by the off-line tools. The revision is based on the expert judgment of the benefits analysis team. See **Chapters 4 and 5** for discussion of program-by-program benefit estimates, including such reductions.

Once each of the programs (or group of programs) is represented individually within NEMS-GPRA05 and MARKAL-GPRA05, the benefits of EERE's portfolio are estimated by combining all of the program goals into one EERE Portfolio Case.

Detailed projections from the EERE Baseline and Portfolio Benefits Case are in **Appendix A**.