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**). **Step 1** provides a consistent baseline for the analysis, which reflects an energy future without EERE's contributions, along with a standard methodology (guidance) to help ensure consistency in estimates across programs. **Step 2** provides the specific technology and market information, which is necessary to understanding the potential roles of each program in its target markets. In **Step 3**, this program and market information is used to assess the impacts of each EERE program, as well as the overall EERE portfolio, on energy markets in the United States using an integrated energy-economic model.[1]

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.
- Meet with program and analysts to review FY 2004 modeling inputs and results.

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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

[1] The FY 2004 benefits assessment was already well underway at the time of EERE's reorganization in June 2002. As a result, the analysis described here and in the appendices is something of a hybrid between the pre-reorganization process and the new process described here.

Step 1: Baseline Case and Guidance

Baseline Case

The EERE Baseline Case is a projection intended to represent the future U.S. energy system without the effect of EERE programs. This Baseline Case is intended to serve four purposes: First, it assures that these initial assumptions are consistent with each other; e.g., that the level of electricity demand expected under the economic growth assumptions could be met at the electricity price assumed. Second, it assures that each program's benefits are estimated based on the same initial forecasts for economic growth, energy prices, and levels of energy demand. 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). Finally, it helps ensure that underlying improvements in efficiency and renewable energy are not counted as part of the benefits of the EERE programs.[2]

EERE utilized the most recent Annual Energy Outlook (AEO) Reference Case as the starting point for developing this base case.[3] The Energy Information Administration (EIA) AEO Reference Case provides an independent representation of the likely 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. Current energy policies, such as state renewable portfolio standards (RPS), which facilitate the development and adoption of these technologies, are included in the Baseline Case. This approach ensures that EERE's benefits estimates do not include expected impacts of such policies.

In establishing its Baseline Case, EERE makes a number of modifications to the EIA Reference Case in order to remove discernable representations of EERE programs and to update policy and market factors where additional information is available. These modifications are made using the same model, the National Energy Modeling System (NEMS), used by EIA in developing the AEO. To distinguish it from EIA's version, the model is referred to as NEMS-GPRA04.

EIA includes some of the impacts of EERE's programs in its Reference Case. These representations are removed from the EERE Baseline Case so that they can be analyzed in the Program Case. Those impacts that are *explicitly* represented in the EIA Reference Case are removed from the EERE Baseline Case. For example, scheduled but not yet completed appliance standards are in the AEO. They are removed for this Baseline Case so that their benefits can be assessed as part of the Building Technologies Program. Beyond the specific program representations, removing the impacts of future program results from the EIA reference case is very difficult. The AEO2002 forecast includes technology improvements in virtually all areas of energy demand and supply; and no clear means of identifying what portion is due to future

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[2] 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.

[3] *The Annual Energy Outlook 2002 with Projections to 2020*, December 2001, DOE/EIA-0338 (2002). See http://www.eia.doe.gov/oiaf/archive/aeo02/pdf/0383(2002).pdf.

EERE program efforts is currently available. In the absence of a clear-cut approach to removing program-induced technology improvement from the Baseline Case, no modifications are made to the technology assumptions of the AEO2002. This approach underestimates EERE program benefits.

The EERE Baseline Case also is updated to reflect new policy or market information. The production tax credit (PTC) for wind and closed-loop biomass, for example, is extended to 2003 in the FY 2004 EERE Baseline Case. The extension was not included in the AEO2002 Reference Case, because the PTC extension occurred after the AEO2002 was completed. Market factors are similarly updated. Residential lighting demand, for example, is substantially increased in the EERE Baseline Case, based on a recent lighting-markets report performed for EERE.[4] This change also was adopted by EIA for the AEO2003 but is not reflected in the AEO2002, on which this analysis was based. Similarly, the limit on the share of generation in each region that can be met with intermittent technologies is raised from a limit of 12 percent to 30 percent, based on experience with the introduction of intermittent power in other countries. Building this updated policy and market information into the Baseline Case, as well as the Program Case, helps ensure that the analysis does not ascribe credit for these external developments to EERE program activities.

The adjustments to the AEO2002 Reference Case result in an insignificant difference in energy consumption. For example, in 2020, conventional energy demand in the AEO2002 Reference Case is 121.9 quads. The EERE Baseline Case value is 120.5 quads, a 0.6 quad difference. If graphed in **Figure 2.2**, the AEO2002 Reference Case data for conventional energy demand would virtually overlay EERE's Baseline Case.

Nonrenewable energy demand in the Baseline Case increases by 21 percent from 2005 to 2020. Underlying energy efficiency and renewable energy improvements, however, contribute toward a 23 percent reduction in conventional energy intensity (conventional energy used per dollar of GDP produced), due to private-sector R&D advances and investments, as well as structural changes in the economy during the same period (**Figure 2.2**).[5] Between 2005 and 2020, renewable energy technology improvements result in increases in electric generation (in billions of kWh) of 17.2 for geothermal, 15.3 for biomass, 6.5 for wind, 5.7 for municipal solid waste, 0.6 for photovoltaics, and 0.2 for solar-thermal. More detail from EERE Baseline Case projections is in **Appendix A**. EERE benefit estimates do not include any of these Baseline Case improvements. Rather, the R&D improvements represented in this case provide the "next best technologies" to which additional EERE improvements are compared.

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[4] Navigant Consulting, *U.S. Lighting Market Characterization, Volume I*, September 2002.

[5] 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).

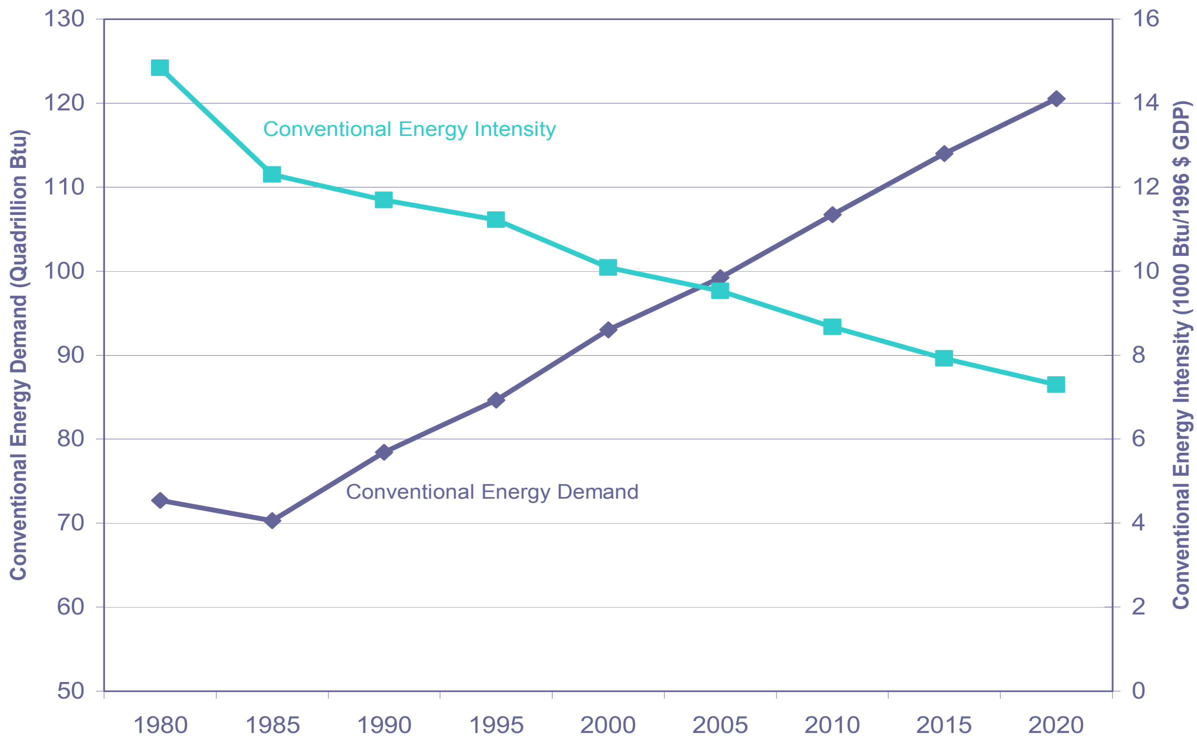

Figure 2.2. U.S. Conventional Energy Demand and Energy Intensity, 1980-2000, and Baseline Projections to 2020

Data Source, 1980-2000: Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384 (2001) (Washington, D.C., August 2002), Tables 1.3, E1 Web site http://www.eia.doe.gov/emeu/aer/contents.html.

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, these common elements were provided in the form of an annual "GPRA Data Call"[6] 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. EERE's benefits analysis is done in constant or real dollars (i.e., without inflation). In cases where future expenditures or costs are provided by the program or other sources in nominal dollars, these are converted to constant dollars based on a forecasted GDP deflator.

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[6] The guidance used for FY 2004 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.

Next best technology. The benefits of EERE technologies are assessed compared to the best technologies otherwise available to the market, not simply 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 model does not have explicit technology representation, the "next best technology" is reflected in the Baseline Case rates of technology and market improvements. EERE assumes that its R&D efforts work principally to 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.[7] 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 fully saturate their target markets, 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 trade-off between upfront investment costs and energy savings over time, as well as other attributes in selected cases. Where technologies are not explicitly represented, adoption rates are embedded in efficiency trends. 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 are assumed to remain the same for the Program Case and the Baseline Case, unless there is a basis for assuming that 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 (TCs) 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.

[7] 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 sector-level appendices to this report.

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**).[1] 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.

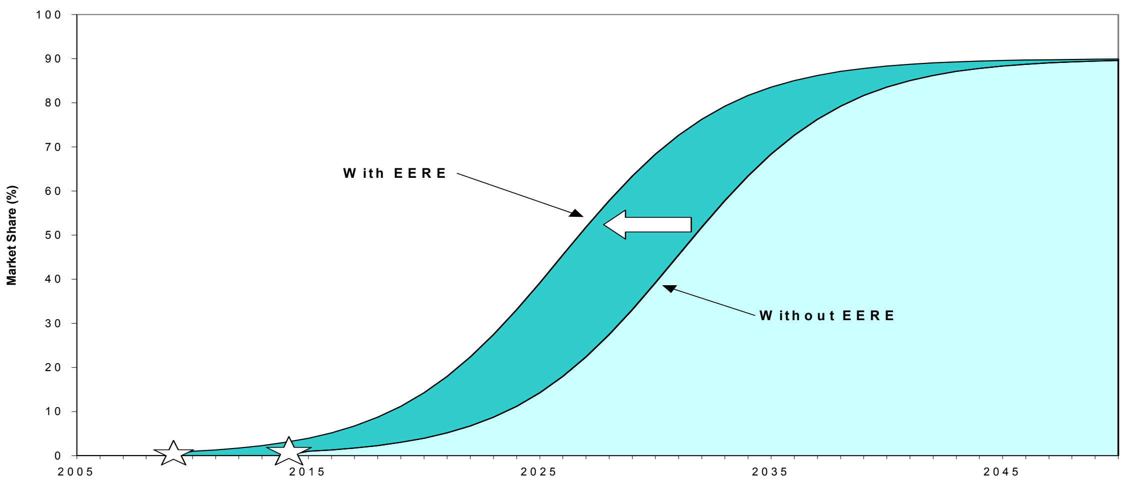

Figure 2.3a. Potential Impacts of EERE R&D Programs on Technology Introduction

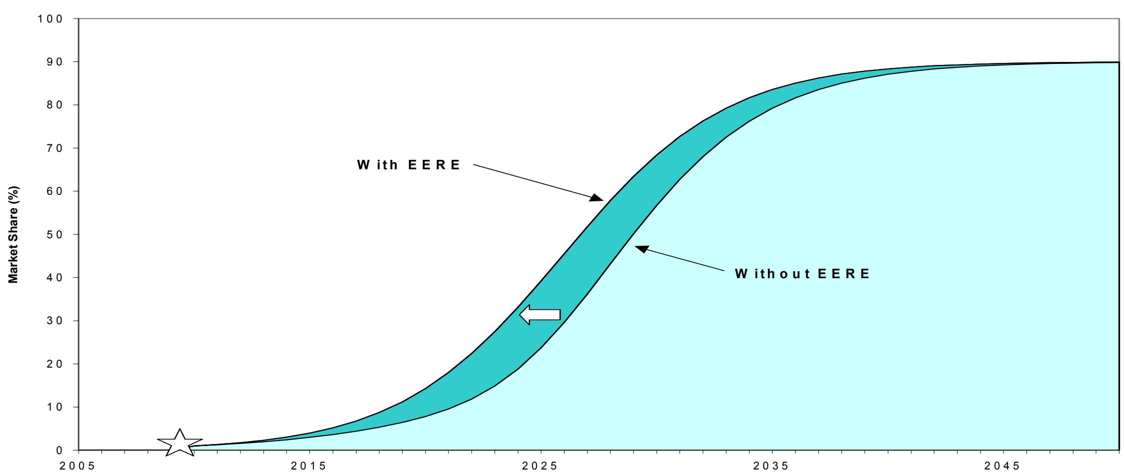

Figure 2.3b. Potential Impacts of EERE Deployment Programs on Market Penetration

*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.

Two sets of TCs are of interest: Baseline Case and Program Case. The EERE Baseline Case already includes expected private-sector advances in efficiency and renewable technologies (see **Figure 2.4**). In many cases, the specific technology characteristics are included directly in the NEMS-GPRA04; 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 are generally reflected in the program output goals.

For example, the Wind Program aims to reduce the cost of wind generation by reducing the capital costs and improving the performance of wind turbines (**Figure 2.4**). These cost and performance improvements reduce the cost of wind energy faster than occurs in the Baseline Case. For deployment activities, the individual technologies targeted are identified in program plans and related materials. For these programs, the TCs remain at their baseline levels. In both the Baseline Case and Program Case, technologies typically improve incrementally over time as research progresses. The additional R&D dollars provided by the program increases the rate of technology improvements.

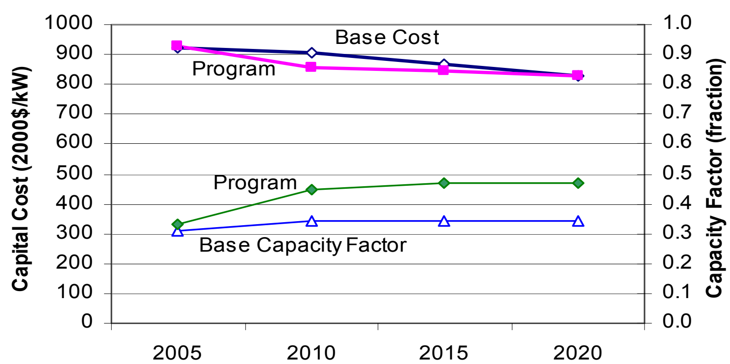

Figure 2.4. Class 4 Wind Capital Cost and Capacity Factor

Calculating direct energy and primary energy displaced. For any given technology, the "wedge" between technology sales under the Program and Baseline cases—which includes all the projected business-as-usual improvements, coupled with relative efficiencies—produce the energy savings (or displacement) attributable to the program. NEMS-GPRA04 provides 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 marginal efficiency of power production will change over time as the mix of displaced plants shifts from existing plants to avoidance of new capacity construction. When the principal market analysis is performed outside of NEMS-GPRA04, and resultant energy savings are used as an input to the model, they are expressed in direct energy terms. The model then computes primary energy savings. (See **Box 2.2 – Energy-Economic Modeling**).

The GPRA04 analysis began under the previous EERE organization, and the programs were requested to compute the full GPRA metrics including primary energy. The guidance provided at the beginning of the analysis included a conversion factor for direct to primary energy that reflected the anticipated shift over time in the marginal sources of energy for power production. Therefore, the supporting documentation (**Appendices B though E**) includes estimates of primary energy savings, even though the final values used in the FY 2004 budget are those from NEMS-GPRA04.

Box 2.2—Energy-Economic Modeling

Markets are fundamentally interactive. Relatively small changes in one energy market are unlikely to generate noticeable changes in other markets. In these cases, a simple "back of the envelope" estimate will suffice in estimating resulting energy savings. However, larger changes in energy markets–or a large number of small changes—can have impacts on the level of energy saved or displaced well beyond the immediate technology. A reduction in home heating and cooling costs, for instance, may result in some "take back" in the form of increased demand for heating and cooling. It also may change the mix of fuels used to produce electricity, over the time frame being analyzed here, especially if peak demand for electricity drops and fewer new power stations are needed. This will reduce the role of conventional power plants, but will also limit the development of wind and other emerging electricity sources. Similarly, a 10 percent improvement in energy efficiency in each residential energy-using device could have a noticeable impact on electricity prices and fuels.

EERE's portfolio generates significant enough changes in energy markets that it is necessary to account for these various feedbacks, up-stream impacts, and cross-market changes in order to develop better estimates of resulting benefits at the Program and EERE Portfolio levels. Mathematical models are useful to provide an internally consistent framework and baseline for the analysis. In models of this type, EERE technologies can compete with each other and with other energy technologies in these respective markets. In addition, the models can represent the extensive interactions among energy markets, such as price changes in response to changes in demand or supply levels, demand response to changes in the prices of technologies, and the potential for fuel switching. Such models also can account for a number of external factors, including fossil fuel prices, economic and demographic growth, and stock turnover.

NEMS-GPRA04 is an energy-economic model that reflects the ways in which energy is currently produced and consumed in the United States, the energy choices consumers make, and the ways in which different parts of our energy markets interact. It contains a detailed slate of energy-using technologies, including their capital costs, operating costs, efficiencies, and other technology characteristics—such as likely improvements in the technologies in the future. From those characteristics, the adoption and penetration of technologies are projected, based on algorithms that represent consumer response based on the capital, O&M, and fuel costs of competing technologies, technology efficiencies, discount rates, equipment replacement rates, and a variety of other consumer preference factors, where applicable. It is also designed to keep track of scores of possible energy paths for supplying energy to consumers. For example, the model helps discern the mix of coal, natural gas, and other energy sources likely to supply the mix of future peak and off-peak electricity loads expected.

While this model compares the costs of different paths for providing electricity and other types of energy to consumers, it also tries to reflect observed market factors beyond price. The model has assumed discount rates used by consumers in making energy investments, which vary substantially by market segment and technology. It also builds in "typical" lag times for market for supplies of new technologies or energy resources and many of the other "market frictions" that can dampen market acceptance of a new technology.

Integrating models differ enormously in terms of the amount of market information included, depending on both the purpose of the model and the data actually available. In general, longer-term modeling must be based on simpler representations of individual energy markets. Some aspects of energy, such as regional variations in energy supplies or prices, can be incorporated into many models—if the information is available at a regional level. The breadth of EERE's portfolio—in terms of markets addressed, geographic regions, and time frame—limit the extent to which any one model, including NEMS-GPRA04, can be relied on in estimating program benefits. Indeed, for much of EERE's portfolio, however, NEMS-GPRA04 does not reflect the level of detail needed here to provide a good understanding of how a particular EERE technology might fare. In these cases, some of the analysis must be undertaken off-line, or outside of the model. In practice, a significant amount of market-specific information must be developed outside or "off-line" from the model. Benefit estimates developed outside of these energy-economic models are reduced by judgment to account for market feedbacks.

Calculating carbon equivalent emissions reductions. Similar to primary energy, carbon emissions are computed using NEMS-GPRA04, based on energy savings that result either from an internal estimation of program impacts on energy markets or from an external analysis of direct energy savings that is used as an input to the model. Much of the growth in electricity generation is expected to be produced from relatively low-carbon natural gas, rather than higher-carbon coal. The resulting carbon emission factors for electricity reflect this lower and changing carbon content for marginal electricity sources. The GPRA 2004 documentation of program analyses also includes estimates of carbon emissions in addition to estimates for primary energy. These are based on direct energy savings and carbon emission factors (the amount of carbon contained in the fuel) that are provided for each fossil energy source and for electricity.

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 current capabilities to reflect specific market conditions in energy models available to EERE.

Other factors have been considered to augment EERE's current analysis. Some of these have been deemed to not have a significant impact on the resulting estimates of benefits and, therefore, have been excluded from the analysis.[8] In some cases, however, empirical evidence or energy-model assessments, or improved data or methodologies, would produce more accurate or robust (i.e., less sensitive to assumptions) benefit estimates. EERE is currently identifying important areas of improvement and prioritizing those improvements with respect to their ability to improve the consistency of EERE's benefit estimates.

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 NEMS-GPRA04 utilizes 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-GPRA04 contains a detailed technology representation of electricity markets, most residential and commercial end uses, and vehicle choice—but uses trends for the representation of industrial efficiency improvements and existing residential shell retrofits. In those first cases where the NEMS-GPRA04 includes both explicit representation of the program technology and target-market characteristics, this step simply requires (1) confirming representation of the target market in the Baseline Case and (2) providing the program goals in a format consistent with the

[8] For example, when market analysis indicated that there is no substantial difference between future average and marginal electricity prices, EERE chose to not include this additional market consideration in its guidance and benefits analysis. By comparison, it turned out that there is a significant difference between average and marginal carbon emissions from electricity production, and ignoring this difference would overstate the climate benefits of EERE technologies. Being able to ignore some market details helps reduce the complexity and cost of benefits analysis, but requires an up-front investment to assess which details can be safely ignored.

model. Any updated market characteristic information is used to adjust NEMS-GPRA04 for both the Baseline Case and the Program Case. The program goal information is used 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-GPRA04.

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, the most detailed off-line analyses are performed for the Industrial Technologies Program, Weatherization and Intergovernmental Program (WIP), Federal Energy Management Program (FEMP), and portions of the Building Technologies Program, along with the heavy-truck portion of the FreedomCAR and Vehicle Technologies Program. These off-line analytical approaches are tailored to the characteristics of the program and target market being analyzed; but, in any case, are conducted within the overall guidance provided through the GPRA benefits estimation process.

Where NEMS-GPRA04 does 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 model. 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.

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.

Off-line analysis also can be required for targeted submarkets that are simply not included in NEMS-GPRA04—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 home efficiency improvements are directly purchased by the Federal Government.

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-GPRA04; and, therefore, another model specifically designed to analyze this market is used. 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, the following features are explored in these external analyses:

Target Markets. New technologies will not necessarily be well suited to all applications served by existing markets. Especially in early years, technologies may occupy niche markets. In some cases, initial markets may be geographically limited as well. Where NEMS does 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. 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 benefits, in particular, may differ from those expected. Modeling stock turnover is crucial to estimating benefits accurately for both new technologies and deployment programs.

Next Best Technology. Where this 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. This set of baseline technologies is then used to assess the specific markets in which the EERE technology might be competitive in different timeframes.

Market Penetration. Over time, new technologies typically make their way into markets—and, therefore, affect energy use—gaining in share of new sales as consumers learn about the availability of the product, manufacturing capacity grows, and product prices fall with economies of scale and learning.[9] 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 before they are generally cost-effective (a niche market). Price, or cost-effectiveness, is often not the only aspect of the new technology or deployment program that shapes its market acceptance. Many nonprice or cost factors affect consumer behavior. Analysts may adjust models and analyses for such factors using judgments based on better information on expected consumer behavior.

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[9] 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).

Only for R&D programs does EERE assume the impact of the program is to accelerate the commercial introduction of a technology—assuming that 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) that could improve the reliability of the electricity grid. This is because the markets do not provide the price signals that would generate profits from these public benefits. In some cases, that may be the only effect.

As an example, the off-line analysis for the Industrial Technologies Program uses a spreadsheet model that provides several possible market penetration curves. A curve is chosen by the analyst, 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, or through the use of NEMS, program analysts produce estimates of market penetration and direct energy savings. However, these "off-line" estimates are not the final/official benefits estimates. These off-line estimates are integrated within the NEMS-GPRA04 model as the final part (Step 3) of the process.

Through the use of a specialized spreadsheet or other models, or through the use of NEMS, the market analysts produce estimates of market penetration and direct energy savings. For GPRA04, they also produced benefits estimates.[10] These, however, are not the final/official benefits estimates. The resulting technology and market data and assumptions are integrated within the NEMS-GPRA04 model, as in the final step of the process.

Step 3: Program and Portfolio Benefits Estimates

The final step for estimating the impacts of EERE's FY 2004 Budget Request begins by each EERE program being modeled separately within NEMS-GPRA04 to the extent possible. In each program NEMS-GPRA04 run, 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. Each program is modeled separately

[10] As EERE's benefits analyses are streamlined under the new organization, the step of producing initial benefits estimates for each program will be eliminated, and information about key market factors will be incorporated directly into the integrated benefits analysis. Key market information will be updated as market conditions change or new market information becomes available. In addition, benefits out to 2050 will be modeled using MARKAL. For programs that cannot be modeled using NEMS or MARKAL, additional tools and judgment will again be used regarding how to integrate such program benefits into the overall analysis.

to derive estimated energy savings without the interaction of the other programs. The results from the program NEMS-GPRA04 runs are then compared to the Baseline Case to measure the individual benefits of the EERE program being analyzed.

A few of the programs were modeled in groups, and then the joint benefits were allocated to the individual programs. This was primarily due to the legacy of the previous EERE organization. The renewable electricity-generation technologies (solar, wind, hydropower, geothermal, and biomass gasification) were one such group. In addition, fuel cell vehicles (from the HFCIT Program) were modeled along with hybrid vehicles and diesel vehicles (from the FCVT Program) and with natural gas vehicles (from WIP). The grouping likely reduces somewhat the benefits of each program, because they compete in the same markets. The detailed representation of how each of the programs was modeled in the EERE Benefits Case is described in **Chapter 4**.

For programs modeled using NEMS-GPRA04 directly, the Benefits Case is computed 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-GPRA04 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.

Program impacts that cannot be easily modeled in detail using NEMS-GPRA04 are estimated using a variety of 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-GPRA04. In cases where the off-line analyses produce a direct estimate of site energy savings, this information is also incorporated, with adjustments, in NEMS-GPRA04 in order to calculate primary energy savings.

Another challenge in estimating benefits is the potential for program results—individually, or in combination—to be significant enough that market responses and interactions need to be considered. Past EERE experience indicates that failure to reflect market responses tends to overestimate some program benefit levels, even if the overall impact on the EERE portfolio is small. NEMS-GPRA04 takes these feedbacks and interactions into account, which off-line tools generally do not.

As such, in many cases,[11] these off-line results are adjusted based on the judgment of the integrated modeling team before using these as inputs into NEMS-GPRA04. As a general rule, the program estimates were reduced in these cases, rather than implemented at the full savings level in the models.

[11] An example exception is the Weatherization Program, which involves direct field application of energy-savings improvement.

The integrated modeling team selected a discounting of 30 percent to be conservative about these programs that could not be economically evaluated.[12]

Once each of the programs (or group of programs) was represented individually within NEMS-GPRA04, the benefits of EERE's portfolio were estimated by combining all of the programs assumptions into one scenario. The purpose of this approach 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.

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

[12] Program energy savings that were estimated outside the integrated model and then used as exogenous inputs to NEMS were discounted, primarily in an attempt to account for integration effects. In most cases, these estimates are derived for single program activities without consideration of other activities within the same program. The 30 percent reduction reflects the overall average decrease in individual program impacts for those programs that can be modeled in NEMS for the portfolio estimates. As such, 30 percent is used as a "rule of thumb" for the balance of the portfolio that cannot be modeled in NEMS-GPRA04 directly. The impact of an activity, such as the industrial Best Practices Program, is generally developed from a Baseline Case that does not include other activities; in this case, other industrial program impacts. In addition, the cost-effectiveness of a technology—and, therefore, its adoption rate—will be affected by the adoption of other technologies. As a result, estimated savings for a single activity is likely to be overestimated. In contrast, program activities that can be modeled in NEMS-GPRA04 based on technology characteristics, both types of interactions are captured internally. Therefore, for single-activity programs estimated outside NEMS-GPRA04, a discount factor is applied to the off-line estimates to make them more comparable. A secondary purpose in discounting the off-line savings is that, in many cases, an economic analysis was not conducted; and, therefore, the savings were not fully justified. Discounting such savings provides a rough but conservative way to account for the uncertainties inherent in the estimates.