PNNL-13766

OFFICE OF
BUILDING TECHNOLOGY
STATE AND COMMUNITY PROGRAMS

Documentation for
FY2002 BTS GPRA Metrics

Building Technology, State and Community Programs
Energy Efficiency and Renewable Energy
U.S. Department of Energy

January 2002

Prepared for Building Technology,
State and Community Programs
by Pacific Northwest National Laboratory

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Executive Summary

Pacific Northwest National Laboratory (PNNL) estimated the FY 2002 energy, environmental, and financial benefits (i.e., metrics) of the technologies and practices in the U.S. Department of Energy's (DOE's) Office of Building Technology, State and Community Programs (BTS). BTS is part of DOE's Office of Energy Efficiency and Renewable Energy (EE), which uses the estimates of benefits as part of its annual budget request.

This report includes a series of documents that detail the approach and methodology used to estimate future energy, environmental, and financial benefits produced by technologies and practices supported by BTS in the fiscal year 2002. An overview is provided that describes the GPRA process and the models used to estimate savings. The results of the forecasted energy savings, consumer cost savings, and carbon benefits for each of the 19 BTS programs are included in individual program summaries and overall results of the FY02 GPRA effort are summarized for all BTS programs. Technical appendixes include the FY02 GPRA Data Call as well as descriptions of the models used, baseline assumptions, and diffusion curve estimates.

Overview

Overview of the FY 2002 GPRA Metrics Process

Pacific Northwest National Laboratory estimated the FY 2002 energy, environmental, and financial benefits (i.e., metrics) of the technologies and practices in the U.S. Department of Energy's (DOE's) Office of Building Technology, State and Community Programs (BTS). BTS falls within DOE's Office of Energy Efficiency and Renewable Energy (EE), which uses the estimates of benefits as part of its annual budget request.

The metrics effort was initiated by EE in 1994 to develop quantitative measures of program benefits and costs. The Government Performance and Results Act (GPRA) of 1993 mandates such estimates of benefits, which are submitted to EE's Office of Planning, Budget, and Management (OPBM) as part of EE's budget request. The supporting analysis and data are used to set strategic goals and objectives within BTS and DOE, to communicate the benefits of EE programs to all interested parties, and to defend the budget before OPMB and Congress.

Estimating the Energy Savings of BTS Programs

Energy savings for the FY 2002 GPRA metrics were based on the FY 2002 budget appropriation and estimated at a program level and then aggregated to the decision unit level. Benefits were estimated for 36 BTS programs and then rolled up into 19 programs and the 8 BTS decision units, as shown in Table 1. BTS's eight decision units fall into one of two broad areas:

- Building Research and Standards, which develops, implements, and coordinates research and development (R&D) that improves the energy efficiency of building components and then uses system design and regulatory activities to integrate these components into building energy systems.[1]

- Building Technology Assistance, which is responsible for accelerating the adoption of energy efficiency and renewable building technologies through technical and financial assistance to states and local communities.[2]

Several different approaches are required to estimate the benefits of the wide array of BTS programs. This section briefly describes the analytical approaches used to estimate energy savings for the FY 2002 appropriated budget for BTS. Greater detail on each BTS program is provided later in this document in program-specific summaries.

The benefits of EE programs and technologies were assessed at an aggregated level as decision units (formerly known as planning units) to simplify cross-sector comparisons and to limit the number of elements being evaluated to a manageable number. Likewise, the benefits were assessed for a limited number of defined metrics:

- energy savings
- environmental benefits
- economic/financial metrics.

[1] "BTS Building Research and Standards Measurement Statement," FY 2002 Budget Request (internal BTS document).
[2] "BTS Office of Building Technology Assistance Mission Statement," FY 2002 Budget Request (internal BTS document).

Table 1. Decision Units and Programs Evaluated for FY 2002 GPRA Metrics

Decision Unit	36 BTS Activities or Technologies	19 BTS Programs Aggregated for GPRA FY 2002 Metrics
State Energy	• State Formula Grants	• State Formula Grants
Weatherization Assistance	• Weatherization Assistance Program	• Weatherization Assistance Program
Community Energy Program	• Rebuild America/Energy Smart Schools • Information Outreach • Training & Assistance for Codes	• Rebuild America/Energy Smart Schools' • Information Outreach • Training and Assistance for Codes
Energy Star Program	• Energy Star: Clothes Washers • Energy Star: Refrigerators • Energy Star: Electric Water Heaters • Energy Star: Gas Water Heaters • Energy Star: Room Air Conditioner • Energy Star: Compact Fluorescent Lights • Energy Star: Dishwashers	• Energy Star
Technology Roadmaps and Competitive R&D	• Technology Roadmaps and Competitive R&D	• Competitive R&D
Residential Buildings Integration	• Residential Buildings R&D • Residential Building Codes	• Residential Buildings R&D • Residential Building Codes
Commercial Buildings Integration	• Commercial Buildings R&D • Commercial Building Codes	• Commercial Buildings R&D • Commercial Building Codes
Equipment, Materials, and Tools	• Advanced Light Sources (Two-Photon Phosphors) • Advanced Light Sources (Solid State Lighting) • Space Conditioning R&D: Residential HVAC Distribution System • Space Conditioning R&D: Advanced Electric Heat Pump Water Heat • Space Conditioning R&D: Commercial Refrigeration • Appliances and Emerging Technologies R&D: Heat Pump Water Heater • Appliances and Emerging Technologies R&D: Compact Fluorescent Lights • Appliances and Emerging Technologies R&D: Roof Top Air Conditioning • Appliances and Emerging Technologies R&D: Dryers • Appliances and Emerging Technologies R&D: Gas Condensing Water Heater • Appliances and Emerging Technologies R&D: Recessed Can Lights • Building Envelope R&D: Electrochromic Windows • Building Envelope R&D: Superwindows • Building Envelope R&D: Quick-Fill Walls • Building Envelope R&D: R30/30 Year Roofs • Analysis Tools and Design Strategies • Lighting and Appliance Standards: Residential Gas Furnace/Boilers • Lighting and Appliance Standards: EPAct Stamdards • Lighting and Appliance Standards: Distribution Transformers	• Lighting R&D • Space Conditioning and Refrigeration R&D • Appliances and Emerging Technologies R&D • Building Envelope R&D: Electrochromic Windows • Building Envelope R&D: Superwindows • Building Envelope R&D: Thermal Insulation and Building Materials • Analysis Tools and Design Strategies • Lighting and Appliances Standards

Environmental and economic benefits (energy cost savings) were keyed directly to energy savings. Therefore, the balance of this overview focuses on just the energy-savings' estimates.

For most of the BTS programs for which estimates were developed, the benefits estimates are broken out by building sector, building type, region, vintage, end use, fuel type, and type of equipment displaced and then aggregated to obtain the benefits for a program or technology. The program and decision unit structure used in this document reflected the structure used in the FY 2002 budget request.

The analysis considered program goals, technology characteristics (including performance and cost), the targeted market, and program milestones. The technologies and practices modeled were chosen as representing a specific program. Not all activities funded by BTS are modeled; activities were selected if they met some minimal threshold of funding and are likely to result in measurable energy savings.

The program characteristics were developed through extensive interaction with the BTS Office Directors and Program Managers. For FY 2002, program characterization summaries were based on information gathered during interviews conducted throughout the summer of 2000. The characterizations were then reviewed and revised during meetings with BTS Program Managers. The program characterizations presented in subsequent sections of this document represent the results of those interviews, reviews, and revisions.

Modeling Methods Used In Estimating Benefits

The BTS GPRA estimates of benefits were calculated using one of three methods:

- National Energy Modeling System (NEMS)
- Building Energy Savings Estimation Tool (BESET)
- Spreadsheets designed for a specific program.

NEMS allows the costs and benefit characteristics of a technology and its market penetration to be linked within NEMS. However, NEMS has difficulty representing some BTS technologies, such as the whole-building programs because NEMS is designed to model specific technologies and not variable groups of technologies.

BESET was built specifically for estimating the benefits of BTS programs and therefore allows various types of programs to be characterized, including whole-building, envelope, and equipment programs. The major disadvantage of BESET is that the penetration rates (i.e., fraction of sales or fraction of installed base) are determined outside the model and therefore are not explicitly linked to the program's cost and benefit characteristics. In addition, BESET cannot model BTS equipment that competes against more than one baseline equipment type.

For programs that are not easily modeled in BESET or NEMS, spreadsheets were used. For example, because BTS's codes and standards programs have already developed its own set of spreadsheet tools for estimating impacts of the building codes programs, these tools were adapted for the GPRA estimation process.

Each of the three methods used for deriving energy-saving estimates for the FY 2002 GPRA metrics is described in more detail in the following subsections.

NEMS

NEMS is the primary midterm forecasting tool of the Energy Information Administration (EIA), used for the projections contained in EIA's Annual Energy Outlook (AEO) and numerous special studies for the U.S. Congress and DOE. NEMS consists of a series of computer simulation models that represent all the major energy supply, demand, and conversion sectors of the U.S. economy. NEMS represents domestic energy markets by explicitly representing the economic decision-making involved in the production, conversion, and consumption of energy products and, where possible, NEMS includes explicit representation of energy technologies and their characteristics.

Most of BTS's technology programs are modeled using NEMS. The commercial and residential energy demand modul1es within NEMS were used to calculate the savings generated by the improved BTS technologies. Energy savings in equipment programs were calculated by comparing new equipment efficiencies with baseline efficiencies.[3]

The NEMS commercial and residential demand modules generate forecasts of energy demand (energy consumption) for those sectors. The commercial demand module generates fuel consumption forecasts for electricity, natural gas, and distillate fuel oil. These forecasts are based on energy prices and macroeconomic variables from the NEMS system, combined with external data sources. The residential model uses energy prices and macroeconomic indicators to generate energy consumption by fuel type and census division in the residential sector.

NEMS selects specific technologies to meet the energy services demands by choosing among a discrete set of technologies that are exogenously characterized by commercial availability, capital costs, operating and maintenance costs, efficiencies, and lifetime (see Figure 1). NEMS is coded to allow several possible assumptions to be used about consumer behavior to model this selection process. For the GPRA effort, the menu of equipment was changed to include relevant BTS program equipment, technological innovations, and standards.
The NEMS design can accommodate various technology choices. For the GPRA FY 2002 metrics, the NEMS data input was adjusted to reflect BTS technology choices. For BTS programs that target shell efficiency, specific shell-efficiency indices were read into the model. The commercial and residential demand modules in NEMS are summarized below.

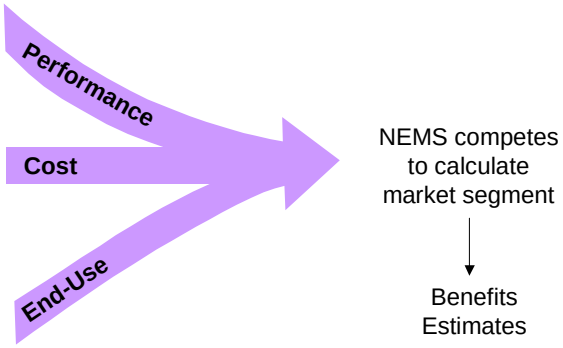

Figure 1. Developing the Market Segment (NEMS)

[3] The FY 2002 metrics used the NEMS model associated with the Energy Information Administration's *Annual Energy Outlook 2000*.

BESET

BESET is a bottom-up accounting model that compares baseline energy use against the BTS technology. BESET also is used to centrally collect, store, and report all results produced by all the various estimation methods. Finally, BESET produces the input files needed for estimating employment impacts developed in a separate modeling environment.

BESET can estimate benefits for various programs: whole building, envelope, lighting, HVAC, cogeneration, and water heating. BESET also contains a "tax" algorithm that calculates the average energy savings per budget dollar for the BTS portfolio so the energy savings can be applied to an umbrella program. Beginning with the FY 2001 GPRA effort, BESET was primarily used to model BTS programs that target whole-building energy use. Although BESET can model equipment and envelope programs, those programs are estimated by NEMS.

To determine energy savings for specific BTS programs, BESET requires information in the following areas:

- **Program Performance Goals.** The goals of each program are assessed in terms of energy savings (e.g., percent load reductions and equipment efficiency improvements) and used as inputs to BESET.

- **Target Market.** Target markets are defined in terms of building sector (e.g. residential and commercial), building type (e.g. single family and commercial education), size (commercial only), income level (residential only), vintage (e.g., new or existing), and climate zone or region. Using the Rebuild America program as an example, Figure 2 illustrates the process used to define the program's targeted market segment within BESET.

  Once the target market has been identified, the penetration into that market is deter-

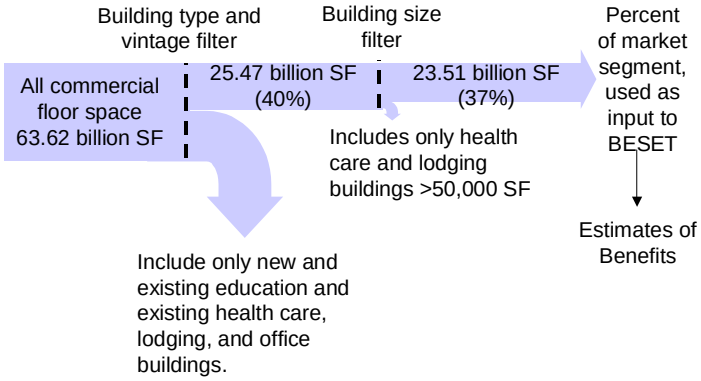

Figure 2. Developing the Market Segment (NEMS): Rebuild America Example

mined using technology diffusion curves (discussed later in this section). Within BESET, market penetration is defined as either the fraction of sales for equipment for new buildings or the fraction of installed base for existing buildings. The penetration model requires only the year of introduction into the market, an estimate of market penetration in 2020 (provided by BTS Program Managers), and the selection of the most appropriate diffusion curve category.

- **Private Investment (Cost).** Estimates of private investment for both the baseline and the BTS technology or practice are entered into BESET. Ideally, the investment costs would be considered when market penetration is developed; however, the current diffusion model used does not incorporate costs at this time. In addition to private investment, non-energy savings program benefits are also quantified when possible and entered into BESET.

The basic steps involved in calculating the energy savings for whole-building programs modeled in BESET are as follows:

1. Determine the size of the potential market.
2. Determine the number of units affected by the BTS program.
3. Determine the base space conditioning, water heating and other end-use loads if appropriate.
4. Determine the space conditioning and water heating end-use loads after the program is implemented.
5. Calculate the energy savings.

All estimates were aggregated through a BESET-NEMS interface. BESET contains a report generator that aggregates the program and technology level benefits into the decision units. The aggregated information is submitted to OPBM to include in the GPRA metrics effort for all EE sectors.

Spreadsheet Models

Whenever possible, programs were modeled within NEMS or BESET to help ensure consistency in baseline inputs and methodology. However, several BTS programs were modeled in spreadsheets because of their unique characteristics. The estimated savings generated by the spreadsheet models were entered by fuel type into "fixed" tables within BESET so that the environmental and energy cost-savings' benefits can be calculated using the same data set as the other programs. Spreadsheets were used to model the following programs:

- **State Formula Grants.** This program was modeled based on historical information that provides an estimated level of savings per program dollar. Because neither BESET nor NEMS are designed for this type of analysis, the program continued to be modeled in a separate spreadsheet.

- **Weatherization Assistance Program.** This program was modeled based on program studies that provide per-household savings' estimates. While these inputs may be able to be translated into load reductions and the program run through BESET, such an effort has not been undertaken. The primary barrier to incorporating this program into BESET is that fuel mix for houses in the target market is significantly different between the BESET baseline and historical Weatherization program data.

- **Information Outreach.** The estimates for the FY 2002 request and appropriation were adopted directly from a study commissioned by BTS.[4]

[4] Messersmith, J. and S.A. Azimi. August 2000. *Communication Effectiveness Analysis for GPRA*. Technologists, Inc.

- **Building Codes.** Building code activities are spread among three BTS decision units. However, because of the interrelationships between the three, savings were estimated for the building codes and standards as a whole. Savings estimates were then allocated among the three primary funding sources:

  – Training and Assistance for Codes (within the Community Energy Program decision unit)
  – Residential Energy Codes (within Residential Buildings Integration decision unit)
  – Commercial Energy Codes (within Commercial Buildings Integration decision unit).

  The long-term impact of DOE's assistance to code activities is based largely on data developed for internal use in building codes and standards. DOE provides a high level of support for states seeking to adopt new energy codes, either based on ASHRAE Standard 90.1 or the International Energy Conservation Code (previously the Model Energy Code). Several states have self-developed codes that are not supported by building codes and standards and are not counted in the estimates of program impact.

- **Competitive R&D.** Estimates were based on savings estimates developed by the winners of the FY 1999 Competitive R&D bidding process.

- **Appliances and Emerging Technologies R&D.** While some technologies within this program were modeled in NEMS, three of the technologies contained either performance or program characteristics that made them difficult to model in NEMS or BESET:

  – Compact fluorescent lights – The compact fluorescent light program had very specific sales targets for a short (three years) period of time, so a spreadsheet estimation was required.
  – Rooftop air conditioning – This program had goals of 10% efficiency improvements applied to 10% of sales. Because of the wide range of commercial rooftop air-conditioning equipment efficiencies and the specific sales goal, the program was modeled in a spreadsheet.
  – Recessed can lights – This program includes lighting technologies that are not specifically called out in either NEMS or BESET so was modeled in a spreadsheet.

- **Space Conditioning R&D: Refrigeration.** The refrigeration savings estimates were based on a report on end-use consumption produced by PNNL, program goals, and other various data sources (Belzer and Wrench 1997). Energy-savings estimates were developed in a spreadsheet model because commercial refrigeration is a service, not a specific piece of equipment, and therefore cannot be modeled in NEMS or BESET.

- **Lighting and Appliance Standards: Distribution Transformers.** Distribution transformers are part of the electricity distribution system, not the building system. Therefore, transformers cannot be modeled in either NEMS or BESET. Savings estimates for a distribution transformer standard were based on a study by Geller and Nadel (1992).

Baseline Inputs

To the extent possible, the underlying assumptions about building stock forecasts, equipment efficiencies, market shares, and end-use loads were consistent across tools (i.e., NEMS, BESET, and spreadsheets). This consistency was accomplished by drawing most of the baseline character-

ization data from the Energy Information Administration (EIA), a statistical agency within DOE. For example, the same version of NEMS used in this document was used to produce EIA's *Annual Energy Outlook (2000)*.

For programs modeled in NEMS, consistency is ensured not only across these programs but also with EIA forecasts. BESET also has a baseline characterization, which is drawn from NEMS, EIA's Annual Energy Outlook, the "Residential Energy Consumption Survey," and the "Commercial Buildings Energy Consumption Survey." The consistency of the baseline assumptions of the spreadsheet tools is verified against EIA's data.

Budget Adjustment Process

The program characterizations that are key to the benefits' estimates are developed through close interaction with the BTS Program Managers. The characterizations require the Program Manager to make assumptions based on the requested level of funding, and the characterization then describes what would be accomplished at that level. However, the budget request amount sometimes changes between the time the characterization is developed and the time the benefits estimates are required. Changes also occur between the final budget request (on which the final estimates are based) and the actual allocation (for which benefits estimates have also been developed to assist in planning).

For small changes in budget levels, a basic "budget adjustment" is made to the program estimates. It is assumed that to get to X savings, a total of Y budget must be spent, where Y is the cumulative budget. A change in the annual budget results in a change in the cumulative budget. Revised savings are calculated for each year as old savings in year z (new cumulative budget in year z/old cumulative budget in year z). This adjustment mechanism implicitly suggests that either the fraction of expected sales or the performance of the program has changed but does not explicitly tie the change to one factor or the other.

For larger changes, the program inputs are revisited with the BTS Program Managers to determine the impact of a reduced (or increased) budget. Options include changing the year of market introduction, changing the impact on sales (market penetration), modifying the performance objective, and adding or removing tasks or technologies within the program (e.g., increased funding in Energy Star may result in developing an Energy Star rating for an additional technology).

The set of energy-savings' estimates documented in this report was produced based on the appropriations by Congress for FY 2002. Several programs had to be re-evaluated when the funding level changed significantly. Therefore, the initial estimates had to be re-estimated.

Technology Diffusion Curves

In 1998, a study was conducted by David Belzer, PNNL, to examine the historical market penetration (i.e., diffusion) for 10 energy-efficient products related to the building sector. Diffusion models were estimated for each product based on the specification proposed by Frank Bass in the late 1960s. The resulting models were incorporated into the GPRA metrics analysis for many of the programs and technologies not modeled within the NEMS framework. The model development and empirical analysis were designed to generate more credible predictions of the adoption process of important energy-efficiency technologies in the buildings sector.

The technologies were placed into four separate categories: lighting, HVAC and refrigeration (HVAC/R), envelope, and design. Two additional categories were added: 1) "Other Equipment" represents an average of lighting and HVAC/refrigeration technologies and 2) "Other Program" represents the envelope category. See Appendix C for a summary of this study.

Contents of this Document

The remainder of this report consists of 19 program descriptions, summarizing information about program's objective, long-term goals, and market and its savings in terms of primary energy savings, carbon equivalent reductions, and consumer cost savings.

Four appendixes provide more detailed information on topics covered in this document. Appendix A details the baseline scenario and inputs used for the FY 2002 metrics. Appendix B contains the GPRA Data Call for FY 2002. Appendix C provides more detailed information on the development of the technology diffusion curves. Appendix D provides detail on the methodology for the GPRA methodology.

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National Appliance Energy Conservation Act of 1987 P.L. 100-12

"Residential Energy Consumption Survey." Latest Edition. U.S. Department of Energy, Energy Information Administration. eia.doc.gov/emeu/recs/contents.html

U.S. Department of Energy, Office of Building Technology, State and Community Programs (internal documents) FY 2002 Budget Requests:

Data Bucket Report for Analysis Tools and Design Strategies Program
Data Bucket Report for Appliances and Emerging Technology Program
Data Bucket Report for Building Envelope: Thermal Insulation and Building Materials Program
Data Bucket Report for Building Envelope: Windows Program
Data Bucket Report for Commercial Building Codes Program
Data Bucket Report for Commercial Building Integration R&D Program
Data Bucket Report for Energy Star Program
Data Bucket Report for Information Outreach Program
Data Bucket Report for Lighting and Appliance Standards Program
Data Bucket Report for Lighting R&D Program
Data Bucket Report for Rebuild America Program
Data Bucket Report for Residential Building Integration R&D Program
Data Bucket Report for Space Conditioning and Refrigeration: Refrigeration Program

Data Bucket Report for State Formula Grants Program
Data Bucket Report for Technology Roadmaps and New and Innovative R&D
Data Bucket Report for Weatherization Assistance Program
Data Bucket Report for Residential Building Codes Program

List of Terms

BESET	Building Energy Savings Estimation Tool
BTS	Office of Building Technology, State and Community Programs
CBECS	Commercial Buildings Energy Consumption Survey
DOE	U.S. Department of Energy
EE	DOE's Office of Energy Efficiency and Renewable Energy
EER	energy efficiency ratio
EIA	Energy Information Administration
EPAct	Energy Policy Act
EPAct	Energy Policy Act of 1992
EREC	Energy Efficiency and Renewable Energy Clearinghouse
GPRA	Government Performance and Results Act of 1993
IEEC	International Energy Conservation Code
NEMS	National Energy Modeling System
OPBM	Office of Planning, Budget, and Management
ORNL	Oak Ridge National Laboratory
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RECS	Residential Energy Consumption Survey
SEER	seasonal energy efficiency ratio

Summary of Benefits

BTS Primary Energy Savings Forecasts Based on FY 2002 BTS Budget Appropriation

The results of the forecasted energy savings, consumer cost savings, and carbon benefits for each of the 19 BTS programs (for 2002, 2010, and 2020) are included in the program summaries in the next section. Tables that include forecasted benefits up to the year 2030 for all programs and decision units are included in a separate document, which is available upon request. The benefit estimates available in that document include the following:

Energy Savings Benefits Tables (TBtu per year)
- Total Primary Energy Savings
- Primary Electricity savings
- Primary Non-Electric Savings
- Site Electricity Savings
- Site Natural Gas Savings
- Site Oil Savings

Environmental Benefits Tables (million metric tons per year)
- Carbon Equivalent Emissions Reductions
- SO_2 Emissions Reductions
- NO_X Emissions Reductions
- CO Emissions Reductions
- PM Emissions Reductions
- VOC Emissions Reductions

Financial Benefits Tables (million $ per year)
- Consumer Cost Savings
- Non-Energy Cost Savings
- Incremental Private Investment

Energy Savings Analysis by Decision Unit

Decision unit benefits are reported annually. The energy savings estimates for 2010 represent energy saved in 2010 only. These are not cumulative benefits estimates. Note, however, that the energy savings in 2010 are a function of all program activities from FY 2002 on, so the number of affected buildings is a cumulative value. For example, the energy saved in 2010 from the compact fluorescent lights programs is the energy saved in 2010 only from all buildings that have had such lights installed any time between FY 2002 and FY2010.

Total primary energy savings for all BTS programs are estimated to reach 1.2 quadrillion Btu (QBtu) by year 2010 and 2.9 QBtu by year 2020. Figure 1 charts annual energy savings for all programs for all years from FY 2002 to 2020.

Of all BTS energy savings (in year 2020), 41% are generated by programs included in the Equipment, Materials, and Tools decision unit (see Figure 2). This decision unit targets efficiency improvements for specific heating, cooling, and lighting equipment as well as shell (e.g., windows, roofs and insulation) efficiency improvements, including standards that impact specific equipment. Equipment, Materials, and Tools makes up about 10% of the overall

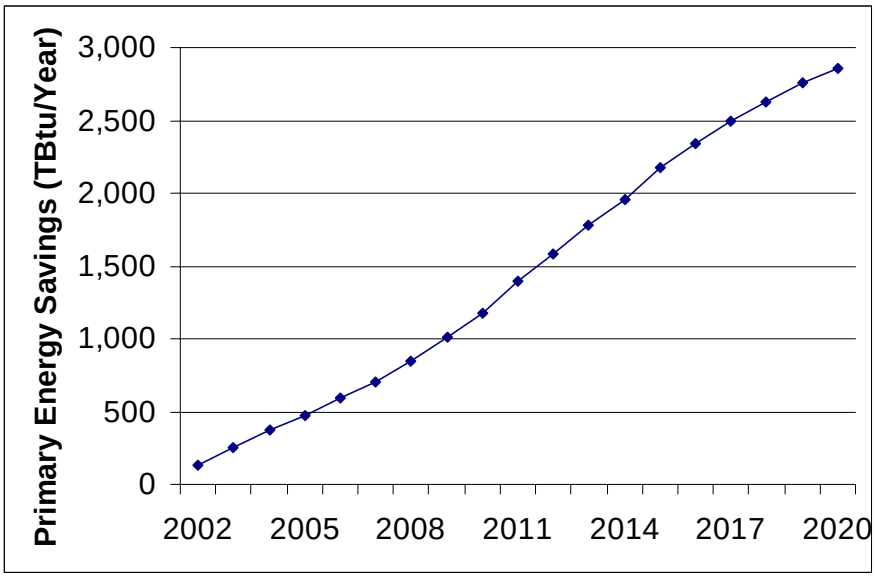

Figure 1. Total BTS Program Primary Energy Savings through FY 2020

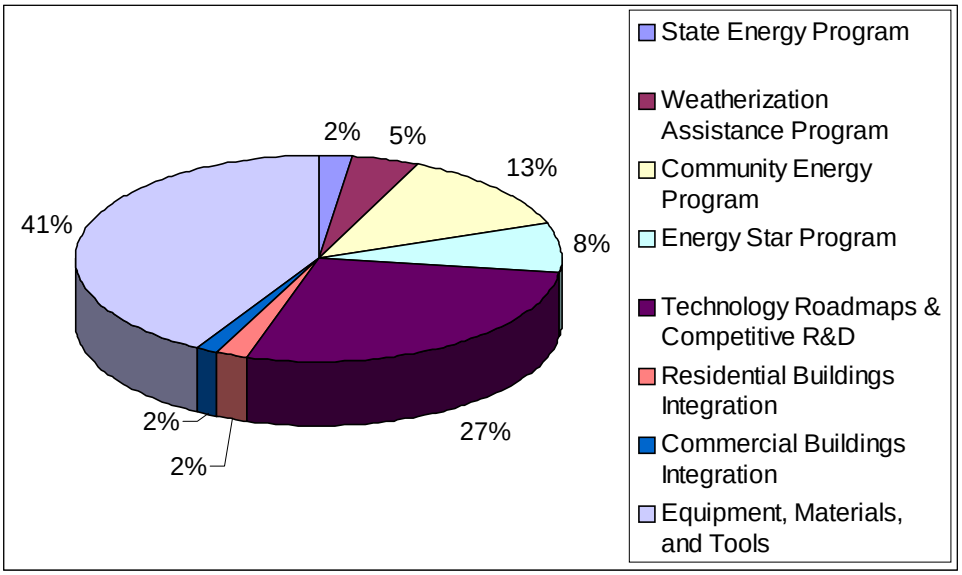

Figure 2. Primary Energy Savings by Decision Unit (for FY 2020)

BTS program FY 2002 budget. Technology Roadmaps and Competitive R&D savings make up 27% of the overall primary energy savings in 2020. While the budget for this program is just 2% of the overall FY 2002 BTS program budget, the competitive procurement funding is provided to industrial partners developing technologies that are close to commercialization. Programs that support the Community Energy Program make up an additional 13% of the overall BTS savings (in year 2020). Community Energy Programs include a combination of programs that target whole-building energy use primarily by providing outreach, education, training and tools, and partnership assistance. Community Energy Programs make up 5% of the overall BTS FY 2002 budget.

In terms of energy savings per budget dollar, the building codes programs and Competitive R&D have relatively high ratios of savings to budget dollar. The building codes programs benefit from having high penetration rates because these standards become regulatory mandates when adopted by states. Competitive R&D has a relatively high level of energy savings per budget dollar because it is a cost-sharing program, where DOE financially collaborates with private sector partners to target particular R&D needs. Programs such as Weatherization and State Energy Programs tend to have relatively low ratios of savings to budget dollar because these programs provide grants and assistance directly to states and households. Figure 3 charts the FY 2002 budget dollars and the energy savings of each decision unit.

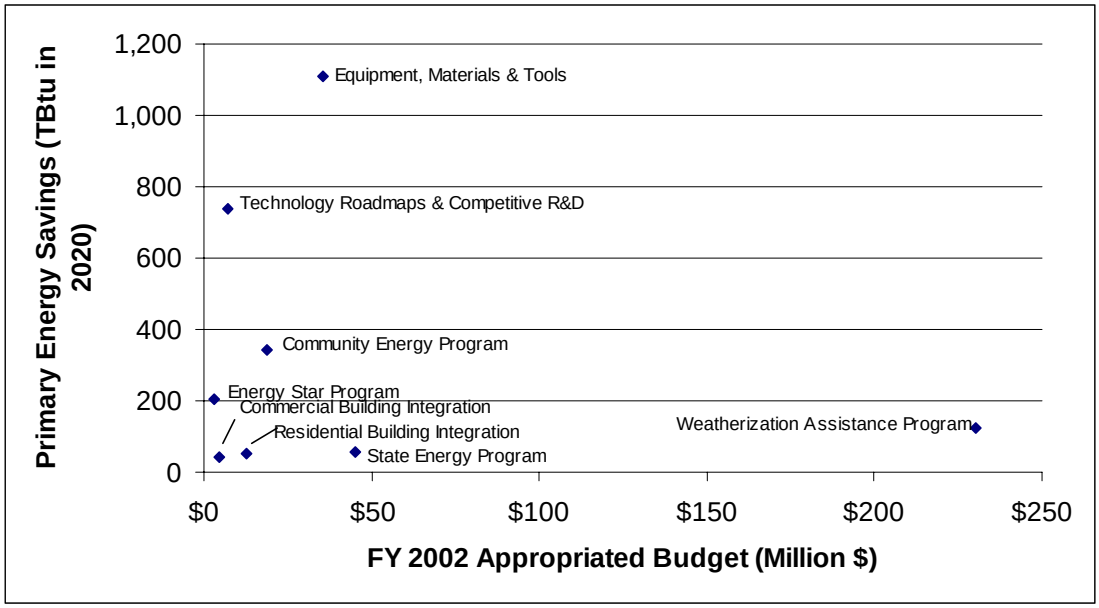

Figure 3. Budget and Energy Savings Scatter Plot for BTS Decision Units

Summary of Benefits

Table 1 summarizes the primary energy savings, the carbon equivalent reductions, and the consumer cost savings for the eight BTS decision units.

Table 1. Summary of Benefits: Analyses of BTS Programs

Decision Unit	FY 2002 Budget (million $)	2002	2005	2010	2020
	Primary Energy Savings (Tbtu/Yr)				
State Energy Program	45	4.7	17.8	35.1	56.0
Weatherization Assistance Program	230	7.4	32.4	71.1	122.2
Community Energy Program	19	49.8	163.7	218.8	341.6
Energy Star Program	3	42.5	120.1	199.8	206.0
Technology Roadmaps and Competitive R&D	7	11.7	76.1	322.0	735.9
Residential Buildings Integration	12	0.3	2.3	17.2	52.5
Commercial Buildings Integration	4	0.3	3.5	9.6	40.7
Equipment, Materials, and Tools	35	13.4	57.2	282.8	1110.3
Totals		130.1	473.2	1157.0	2665.1
	Carbon Equivalent Emission Reductions (MMTC/Yr)				
State Energy Program	45	0.1	0.3	0.6	1.0
Weatherization Assistance Program	230	0.1	0.5	1.2	2.0
Community Energy Program	19	0.9	2.9	3.7	6.0
Energy Star Program	3	0.8	2.2	3.4	3.6
Technology Roadmaps and Competitive R&D	7	0.2	1.4	5.4	13.1
Residential Buildings Integration	12	0.0	0.0	0.3	0.8
Commercial Buildings Integration	4	0.0	0.1	0.2	0.7
Equipment, Materials, and Tools	35	0.3	1.0	4.7	19.2
Totals		2.4	8.5	19.4	46.5
	Consumer Cost Savings (million $/yr)				
State Energy Program	45	28.4	111.1	246.3	406.3
Weatherization Assistance Program	230	51.0	226.8	523.8	891.9
Community Energy Program	19	307.1	1047.6	1627.5	2671.5
Energy Star Program	3	291.9	871.8	1731.7	1836.2
Technology Roadmaps and Competitive R&D	7	75.4	511.1	2544.5	6074.3
Residential Buildings Integration	12	1.7	16.3	130.2	400.5
Commercial Buildings Integration	4	1.9	22.6	69.5	306.4
Equipment, Materials, and Tools	35	87.0	384.6	2146.5	8615.2
Totals		844.4	3192.0	9020.1	21202.2

State Energy

State Formula Grants

State Energy Program Decision Unit

Program Objective:[1]

The State Formula Grants program emphasizes outreach, technology deployment, and forming partnerships to accomplish energy efficiency and renewable energy projects at the state and local level. The program supports the federal/state partnerships that are crucial to developing energy policies and deploying energy technology. The program provides a supportive framework with sufficient flexibility to allow states to address their energy priorities in concert with national priorities.

Long-Term Goal:[1]

The program's strategic plan for the 21st century establishes three key goals to be accomplished by 2010: 1) maximize energy, environmental, and economic benefits through increased collaboration at the federal, state and community level; 2) increase market acceptance of energy efficiency and renewable energy technologies, practices, and products; and 3) use innovative approaches to reach market segments and meet policy goals not typically addressed by market-based solutions.

Market Segment:

Target Market

- **Market Description:** All markets (including buildings, transportation, industry, and power technologies) except new construction and all categories of energy end use.

Methodology

For the GPRA metrics, the State Formula Grants program is characterized based on an estimated level of savings per budget dollar, budget request, and leveraged funds. The basic assumptions are derived from a spreadsheet provided by the program in FY 1999. The assumptions were revised slightly because of external peer review by A.D. Little. The revisions are outlined in the sections below.

Estimated Savings Per Budget Dollar:

For the FY 2001 metrics, each program dollar was assumed to yield 0.0063 MBtu of delivered electricity savings and 0.012 MBtu of other fuel savings per year. These figures are based on an historical review of program savings from 1987-1993, as provided in the pro-

State Formula Grants

Program Type:
Grant

Target Market:
All sectors in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
Energy savings per budget dollar

Modeling Tool:
Spreadsheet

Program Manager:
Faith Lambert

Website:
http://www.eren.doe.gov/buildings/state_energy/

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
4.7	17.8	35.1	56.0

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.089	.330	.621	1.027

Consumer Cost Savings (million $)

2002	2005	2010	2020
28	111	246	406

gram spreadsheet. To develop energy savings by fuel type for other fuel savings, a split of 75% natural gas and 25% fuel oil was assumed.

While this same level of savings was used initially for the FY 2002 effort, it was modified based on the A.D. Little peer review. Based on concerns about the historical versus future project mix, savings based on recycling and wood and biomass renewables were removed. These revisions resulted in an estimate of 0.0044 MBtu of delivered electric savings and 0.0065 MBtu of other fuel savings per program dollar per year. For FY 2002, the fuel split was modified to reflect historical information, yielding a split of 20% natural gas and 80% fuel oil. The savings also were split between the residential and commercial sectors (with the commercial sector representing savings from industrial, transportation, and utilities) based on the historical split of savings (7% residential and 93% nonresidential).

Budget Request and Leveraged Funding:
The estimated energy savings were calculated using the FY 2002 appropriated budget, the budget forecast for FY 2002 - FY 2030, and a leveraged funding forecast. Funds were assumed to be leveraged at a ratio of $4 for every budget dollar. For FY 2002, the estimates were based on the appropriated budget of $45 million, with future projections that this level of funding would remain constant through the analysis period.

Non-Energy Benefits:

Cleaner air and water, increased jobs, enhanced national security, increased economic competitiveness in world markets, and mitigation of global warming.[1]

Program Strategy (% of budget):

- Research and Development – 0%
- Market Transformation – 95%
- Codes and Standards – 5%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for State Formula Grants Program* (internal BTS document).

Weatherization Assistance

Weatherization Assistance Program

Weatherization Assistance Program Decision Unit

Program Objective:[1]

The Weatherization Assistance Program provides cost-effective energy-efficiency services to low-income constituencies who otherwise could not afford the investment and who would benefit significantly from the cost savings of energy-efficiency technologies. The program focuses on households that spend a disproportionate amount of their income for energy, giving priority to households with elderly members, persons with disabilities, and children.

In 1999 the Weatherization network of state and local agencies adopted a new strategic vision for the program called Weatherization *Plus*. The new strategy emphasizes a shift to the whole-house approach and includes electric baseload measures and incorporates advanced technologies. Within the new $2500 legislative cap on average expenditure per household, the mix of measures will include those with enhanced impacts on greenhouse gas emissions and pollution reduction. Such measures include intensified building envelope and heating/cooling system measures, more health and safety measures (supporting other community goals), and more baseload uses such as water heating and lighting.

Long-Term Goal:[1]

The long-term goal of the Weatherization Assistance Program is to achieve 30% energy savings in 1.8 million or 3 million existing low-income homes by 2010, depending on future budget appropriations.

Market Segment:

Target Market

- **Market Description:**. Low-income homes and targets measures that include air sealing; caulking and weather stripping; furnace and boiler tuneup, repair, and replacement; cooling system tuneup and repair; replacement of windows and doors; addition of storm windows and doors; insulation of building shells; replacement of air conditioners; ceiling, attic, and whole-house fans; evaporative coolers; screening; and window films.[2] Weatherization *Plus* would expand this strategy to include water heating, refrigeration, lighting, and cooling.[1]
- **Size of Market:** About 29 million eligible low-income homes.

Weatherization Program

Program Type:
Envelope/Grant

Target Market:
Low-income residential housing in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
Energy-savings per budget dollar

Modeling Tool:
Spreadsheet

Program Manager:
Greg Reamy

Website:
http://www.eren.doe.gov/buildings/weatherization_assistance/

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FY 2002 Benefits

Primary Energy Savings (TBtu)

2002	2005	2010	2020
7.4	32.4	71.7	122.2

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.125	.537	1.161	2.002

Consumer Cost Savings (million $)

2002	2005	2010	2020
51	227	524	892

Methodology

For the GPRA metrics, the Weatherization Assistance program is characterized based on an estimated level of savings per household, cost to weatherize each household, budget request, and leveraged funds and an assumed life expectancy of 15 years for weatherization measures. The basic assumptions are derived from a weatherization spreadsheet provided by the Weatherization program in September 2001.

Estimated Savings Per Household:

For FY 2002, the savings per household used for each region are shown in the table below.

Region	Regular Household Savings (MMBtu/yr)	*Plus* Household Savings (MMBtu/yr)
South	22.25	24.23
Northeast	31.20	46.04
West	19.04	20.31
Midwest	31.20	49.21

The figures in the table were calculated based on a 1997 Metaevaluation report[2] by Oak Ridge National Laboratory (ORNL), a 2001 ORNL draft report entitled *Meeting The Challenge,*[4] and special tabulations from the 1997 Residential Energy Consumption Survey.[5] Previous years' estimates were based on program resource allocations at levels reflecting a formula bias towards homes in colder climates in the northeast and midwest. The higher appropriations levels projected for FY 2002 and beyond will be allocated under a formula that shifts a higher proportion of new revenues to the south and west, where savings rates are lower.

Of the units weatherized in FY 2002, 20% were assumed to have the higher savings rates associated with Weatherization *Plus*. These savings rates were calculated regionally in the ORNL 2001 draft report[4] and multiplied times the expected number of *Plus* households in each region.

To develop energy savings by fuel type, the fuel split was based on historical Weatherization program data in the 1997 ORNL report,[2] regarding the primary heating fuel of weatherized households. Because the GPRA metrics are reported only for electricity, natural gas, and fuel oil, the other fuel percentages were allocated within those types based on similarities of emissions. The split was allocated as shown in the table below.

Primary Heating Fuel	% of Weatherized Households	Categorized As
Natural Gas Liquid Propane Gas	50.6 13.2	Natural Gas
Fuel Oil Kerosene Other (includes wood and coal)	16.0 3.2 7.5	Fuel Oil
Electricity	9.5	Electricity

Cost to Weatherize Each Household:

For FY 2002, $1,725 was used as an average cost to weatherize each household, not including training and technical assistance and administrative costs.[1] Incremental investment for Weatherization *Plus* homes, estimated at an average of $1,400, was assumed to be derived from leveraged funds. Estimated costs by region for *Plus* homes are shown in the following table.

Region	Cost per *Plus* Household
South	$2,861
Northeast	$3,674
West	$1,814
Midwest	$3,429

Budget Request and Leveraged Funding:

For FY 2002, leveraged funding of $235 million per year was assumed. A 20% program overhead was subtracted from the total before calculating the number of households weatherized with these funds. Leveraged funding for the DOE *Plus* homes was

estimated to total $34.7 million in FY 2002, based on the costs reflected in ORNL's *Meeting The Challenge*.[4] The balance of leveraged funds were assumed to be used on regular and *Plus* homes in a 70/30 ratio in FY 2002.

Non-Energy Benefits:

A net present value of $161 per household[3] (1989 $), adjusted for inflation, was proposed for the FY 2002 effort, based on the estimated non-energy benefits resulting from enhanced property values and extended lifetimes of the dwellings, reduced fires, and reduced arrearages.

Program Strategy (% of budget):

- Research and Development – 0%
- Market Transformation – 100%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report of Weatherization Assistance Program* (internal BTS document).

(2) Berry, L.G., M.A. Brown, and L.F. Kinney. 1997. *Progress Report of the National Weatherization Assistance Program*, ORNL/CON-450, Oak Ridge National Laboratory.

(3) Brown, M.A., L.G. Bery, R.A. Balzer, and E. Faby, 1993, *National Impacts of the Weatherization Assistance Program in Single-Family and Small Multifamily Dwellings*, ORNL/CON-326, Oak Ridge National Laboratory.

(4) Schweitzer, M., Eisenberg J.F. November 2000, *Meeting the Challenge: The Prospect of Achieving 30 Percent Energy Savings Through The Weatherization Assistance Program*, Draft Analysis. Oak Ridge National Laboratory, ORNL/CON 479.

(5) Eisenberg, J.F., Oak Ridge National Laboratory. Special tabulations for the Weatherization Population derived from the 1997 Residential Energy Consumption Survey.

Community Energy

Rebuild America/Energy Smart Schools

Community Energy Program Decision Unit

Program Objective:[1]

The Rebuild America program builds collaborative partnerships with states and communities to help them develop and implement environmentally and economically sound activities through smarter energy use. The program connects people, resources, proven ideas, and innovative practices to solve problems. The program provides one-stop shopping for information and assistance on how to plan, finance, implement, and manage retrofit projects to improve buildings' energy efficiency and helps communities find other resources on renewable energy applications, efficient new building designs, energy education, and other innovative energy conservation measures. Rebuild America supports the public/private Energy Smart Schools initiative and competitive Community Energy Grants to encourage community-wide energy projects.

Long-Term Goal:[1]

The program's long-term goals by 2010 include the following: 2000 partnerships, 4 billion sq ft committed to retrofit (~5% of the market, 2 million sq ft/partnership), $6 billion in private investments committed, 0.2 quad of energy saved, and $1.3 billion/year savings.

Market Segment:

Performance Objective:

- **Displaced Technology:** Current design/building practices.
- **Performance Target:** Reduce whole-building energy use of retrofitted and new buildings by 40%/sq ft by 2010 (this is characterized by a 71% load reduction in space heating, space cooling, and water heating by 2010, which is equivalent to whole-building energy reduction of 40%).[2]

Target Market

- **Market Description:** Existing commercial and institutional buildings. General target market includes new and existing multifamily housing, public and assisted single-family residential units, and commercial buildings, particularly, new and existing assembly, health care, lodging, office, education buildings.[3]
- **Market Size:** See the following table.
- **Penetration Goal:** 2,000 partnerships retrofitting 2 million sq ft each by 2010. See table below for resulting penetration rates.

Rebuild America

Program Type:
Whole Building

Target Market:
Existing multifamily residential units >$25,000/yr income and the commercial sector in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
% load reduction

Modeling Tool:
BESET

Program Manager:
Daniel Sze

Website:
http://www.eren.doe.gov/buildings/rebuild/

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
1.2	15.0	41.1	47.4

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.021	.250	.651	.770

Consumer Cost Savings (million $)

2002	2005	2010	2020
8	99	296	350

Market Segments and Sectors	Floor Space (billion sq ft)	Energy Use/ Yr (TBtu)
Commercial Total	67.9	5,800
Commercial Local and State	16.5	1,480
Commercial Private	51.4	4,320
Residential Total	26.8	1,957
Residential Public/Assisted Housing	4.8	450
Residential Private Multifamily Housing	22.0	1,507
Total Commercial and Residential	94.7	7,757

Building Type	Vintage	Penetration Rate			
		Region	2010 (%)	2020 (%)	2030 (%)
Assembly	New & Existing	North & South	3.5	4.0	4.0
Education	New & Existing	North & South	3.5	4.0	4.0
Health Care	New & Existing	North & South	3.5	4.0	4.0
Lodging	New & Existing	North & South	3.5	4.0	4.0
Office, Large	New & Existing	North & South	3.5	4.0	4.0
Office, Small	New & Existing	North & South	3.5	4.0	4.0
Multifamily	New & Existing	North & South	3.5	4.0	4.0
Single Family	New & Existing	North & South	.12	.13	.13
North = zones with >4,000 heating-degree days; south = zones with <4,000 heating-degree days.					

Methodology

Of the 300 million sq ft added to the program each year, it is assumed that not all of the square footage per partner would be retrofit in one year, but that retrofits (and actual savings) would occur evenly over four years. Penetration rates were calculated using the square footage affected by the program as a percentage of the total square footage in the existing building stock. The load reductions specified in the performance objective were applied to the baseline end-use loads to determine energy savings at the building level. These energy savings were translated into national energy savings using the penetration rates and building stock within the target market and then adjusted using the most recent budget request.

Non-Energy Benefits:[1]

Revitalized neighborhoods and business districts, improved school facilities, better low-income housing, and positive economic impact from keeping dollars locally and increasing property values.

Program/Technology Consumer Costs:

- **Cost of Conventional Technology:** Average of $81/sq ft for new commercial and multifamily; $0 for existing buildings.
- **Cost of BTS Technology:** $82.60/sq ft for new commercial and multifamily; $3/sq ft (2001 to 2009), increasing to $4/sq ft (2010 to 2030) for existing buildings.
- **Incremental Cost:** 2% above base for new buildings; $3/sq ft (2001 to 2009) increasing to $4/sq ft (2010 to 2030) for existing buildings.

Program Strategy (% of budget):

- Research and Development – 0%
- Market Transformation – 100%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Data – *Bucket Report for Rebuild America Program*.

(2) Table 1.3.6, *BTS Core Databook* (1999) (internal document) was used to develop equivalent reductions in space heating and cooling and water heating loads.

(3) From a phone conversation with Mark Bailey, former Rebuild America program manager, May 30, 2000. Note the change from previous years where only lodging, health care, office, and education buildings were targeted.

Information Outreach

Community Energy Program Decision Unit

Program Objective:[1]

The Information Outreach program provides BTS with the technical assistance needed to conduct the various planned activities that will educate target audiences. Specifically, the program conceptualizes, plans, and implements a systematic approach to the marketing and communication objectives and evaluation of the programs it supports.

Long-Term Goal:[1]

By 2010, the program's goal is to support long-term success in developing energy-efficient systems and processes and to improve technology transfer/information exchange.

Market Segment:

Methodology[2]

A slightly modified version of an evaluation conducted for the Information Outreach program was used to estimate this program's GPRA benefits. This section draws extensively from the report[2] of that evaluation, which was conducted for protocols used by major public relations firms and prominent measurement organizations. The major aspects of the evaluation protocols are as follows:

- Preparation (BTS activities)
  - Adequacy of background information base for designing the program
  - Appropriateness of the message and activity
  - Quality of the message and activity presentations.
- Implementation (distribution effectiveness)
  - Number of messages sent to media and activities designed
  - Number of activities placed and activities implemented
  - Number who receive messages and activities
  - Number who attend to messages and activities.
- Impact (action taken)
  - Number who learn message content
  - Number who change opinions
  - Number who change attitudes
  - Number who behave as desired
  - Number who repeat behavior
  - Social and cultural change.

Information and data from BTS programs, EIA, and the *BTS Core Data Book*[3] were used within the protocol to estimate energy savings resulting from communications

Information Outreach

Program Type:
Information/Education

Target Market:
New residential and existing commercial in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
Energy savings per budget dollar

Modeling Tool:
Spreadsheet

Program Manager:
Lani McRae

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
44.9	126.0	105.8	99.6

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.837	2.270	1.777	1.756

Consumer Cost Savings (million $)

2002	2005	2010	2020
277	802	780	762

activities. This evaluation was limited to the major communication deployment efforts supported by BTS. The deployments examined include tradeshows and conferences, BTS web sites, direct mail (including newsletters), Energy Efficiency and Renewable Energy Clearinghouse (EREC) distribution, hotline, media, and training handouts/tools.

The methodology is summarized as follows:

1. Choose measurable target audiences from BTS strategic plan (e.g., homeowners, commercial builders, and building retrofit decisionmakers) who can implement a BTS strategy, tip, or technology.
2. Determine the energy-savings' potential of each representative in target group from the *BTS Core Data Book*,[3] BTS programmatic experience, and EIA.
3. Count the total number of impressions from each distribution method and determine how many resulted from commercial builders, building retrofit decisionmakers, and individual homeowners (target group) (see the table).
4. Use industry accepted norms to determine what percentage of the target audience who received message are likely to change their opinion or behavior.
5. Multiply the results in step 4 for each distribution mechanism by the Btu savings' potential calculated for each target audience member in step 2.

The evaluation prepared for the program estimated a total primary energy savings over a 2½ year period of 34.8 Tbtu, resulting in annual energy savings of 13.92 TBtu. The evaluation further assumed that savings lasted for 3 years, after which they are supplanted by activities the decisionmaker would have undertaken in any event. As a result, savings increase over three years to 41.76 TBtu (13.92 x 3) and then stay constant. In the evaluation,[2] the savings were assumed to be 5% residential and 95% commercial, based on the types of decisionmakers the program reaches. The fuel distribution of the savings was assumed to match that of the rest of the BTS portfolio.

Non-Energy Benefits:[1]

New ideas and technologies, the diversity of stakeholders, and changing stakeholder needs, assumptions, and perceptions all increase the challenges of organizing information and communicating effectively. The American public understands and takes into account the energy benefits of energy usage during purchases, giving the consumer more discretionary dollars.

Program Strategy (% of budget):[1]

- Research and Development – 0%
- Market Transformation – 100%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Information Outreach Program* (internal BTS document).

(2) Messersmith, J., and S.A. Azim. August 2000. *Communication Effectiveness Analysis for GPRA*. Technologists, Inc.

(3) *BTS Core Data Book*, 1999, internal document.

Number of Instances a BTS Key Message was Seen or Heard				
Deployment	**FY 2000**	**FY 1999**	**FY 1998**	**Cumulative Impact**
Conferences (attendees)	46,300	66,650	1,000	113,950
Internet (page views)	1,065,477	2,455,135	756,426	4,277,038
Media (circulation	762,750,432	941,645,457	1,602,561,617	3,306,957,506
Direct Mail (recipients)	35,812	120,064	30,300	186,176
EREC (recipients	17,783	58,984	68,294	145,061
Training (hand-outs)	0	3,500	872	4,372
Hotline (calls)	0	800	1,623	2,423
Totals	763,915,804	944,350,590	1,603,420,132	3,311,686,526

Training and Assistance for Codes

Community Energy Program Decision Unit

Program Objective:

While the Training and Assistance for Codes program receives separate funding allocation, the program is characterized as part of the Residential Building Codes and Commercial Building Codes programs. The benefits for this program are broken out separately from those programs.

For information on this program, see the documentation for Commercial Building Codes and Residential Building Codes programs.

Training and Assistance for Codes

Program Type:
Information/Education

Target Market:
New residential and commercial buildings in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
Savings as the percentage of compliance improvement

Modeling Tool:
Spreadsheet

Program Manager:
Jean Boulin

Website:
http://www.eren.doe.gov/buildings/codes_standards/bldgstds.htm

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
3.6	22.7	71.9	194.6

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.069	.417	1.225	3.500

Consumer Cost Savings (million $)

2002	2005	2010	2020
23	147	552	1,560

Energy Star

Energy Star

Energy Star Decision Unit

Program Objective[1]:

The Energy Star program increases the market penetration of high-efficiency appliances, windows, and lighting products through consumer education and voluntary industry partnerships. This program works closely with the private sector to bring new technology into the market through approaches such as high-volume purchases, utility program coordination, product testing, labeling, sales training, and provision of technical information to key segments of the market.

Long-Term Goal:[1]

The program's long-term goal is to achieve a sustained market share of high-efficiency appliances of 20% by 2010.

Market Segment:

Performance Objective:

- **Displaced Technology:** Conventional equipment, appliances, and lights.
- **Performance Target:** Varies by equipment type and size. The following represents a sample of typical Energy Star products on the market:
  - Clothes washers – depends on size and type
  - Refrigerators – typical refrigerators using ~400 kWh/year
  - Electric water heaters – energy factor exceeds .9
  - Gas water heaters – energy factor exceeds .6
  - Room air conditioners – range from 5000 to 1400 Btu/hr, depending on size of unit
  - Compact fluorescent lights – typical product would have efficacy of 60 lumens/watt
  - Dishwashers – typical product would use 400 to 450 kWh/year.

Target Market

- **Market Description:** Determined by program equipment; for FY 2002, the following equipment is characterized:
  - clothes washers (residential)
  - refrigerators (residential)
  - electric water heaters (residential and commercial)
  - gas water heaters (residential and commercial)
  - room air conditioners (residential)

Energy Star

Program Type:
Market Transformation

Target Market:
Commercial sector and residential housing with >$25,000/yr incomes in all climate zones

End Uses:
Heating, cooling, water heating, lighting, and appliances

Unit of Measurement:
Load/efficiency per affected unit for appliances, air conditioning, water heating, and lighting

Modeling Tool:
NEMS for appliances, air conditioning, and water heating. Spreadsheet for compact fluorescent lights.

Program Manager:
Bill Noel

Website:
http://www.energystar.gov

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FY 2002 Benefits

Primary Energy Savings (TBtu)

2002	2005	2010	2020
42.5	120.1	199.8	206.0

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.793	2.185	3.376	3.625

Consumer Cost Savings (million $)

2002	2005	2010	2020
292	872	1732	1836

- compact fluorescent lights (residential and commercial)
- dishwashers (residential).

Methodology

Clothes washers, refrigerators, electric water heaters, gas water heaters, dishwashers, and room air conditioners were modeled in NEMS using input from EIA's *Annual Energy Outlook 2000*. NEMS inputs were determined such that a 20% market share is obtained for Energy Star level appliances.

Compact fluorescent lights were modeled in BESET assuming a market penetration of 20% of the incandescent market in the residential sectors by 2010.

Non-Energy Benefits: (1)

Increased comfort for residential homeowners and office workers and higher profits for manufacturers.

Program Strategy (% of budget): (1)

- Research and Development – 1%
- Market Transformation – 99%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Energy Star Program* (internal BTS document).

Tech Roadmaps
and
Competitive R&D

Competitive R&D

Technology Roadmaps and Competitive R&D Decision Unit

Program Objective[1]:

The Competitive R&D program creates a shared vision among diverse groups within each sector and provides a framework for cooperative technology development.

Long-Term Goal:[1]

The program's long-term goal is to displace 90 TBtu in FY 2010 and 160 TBtu in FY 2020, saving almost $700 million and $1.3 billion, respectively.

Market Segment:

Target Market

- **Market Description:** Lighting, windows, commercial buildings, and heating, cooling, ventilation, and refrigeration.
- **Market Introduction:** Technology-dependent.
- **Market Penetration Goal:** Assumed to be as specified in the 19 proposals funded in FY 1999 as part of the competitive R&D solicitation. A composite market penetration curve was developed based on the available information in those proposals.

Methodology

The benefits for this program are based on the adjusted energy savings from the 19 proposals funded in FY 1999. The adjusted average energy savings per dollar of investment were used to estimate the FY 2002 program energy savings. Adjustments were required to account for the projects competing for the same market as another BTS program. This adjustment was made by dividing the market between programs as appropriate. Therefore, the two programs split the market.

If a targeted technology complements a BTS program, the project does not get credit for the entire market. The project either shortens the time to market penetration or increases the final market penetration.

Program/Technology Consumer Costs:

- **Cost of Conventional Technology:** Technology-dependent.
- **Cost of BTS Technology:** The incremental cost of the BTS technology will be determined based on the average cost across the proposals.

Competitive R&D

Program Type:
ìOtherî -- R&D Mapping

Target Market:
No specific markets defined

End Uses:
No specific end uses or fuel types

Unit of Measurement:
Energy savings per budget dollar

Modeling Tool:
Spreadsheet

Program Manager:
John Ryan

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
11.7	76.1	322.0	735.9

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
0.219	1.380	5.428	13.078

Consumer Cost Savings (million $)

2002	2005	2010	2020
76	511	2545	6074

Competitive R&D

Technology Roadmaps and Competitive R&D Decision Unit

Program/Technology Non-Energy Costs:

- **Cost of Conventional Technology:** Technology-dependent.
- **Cost of BTS Technology:** Technology-dependent.
- **Incremental Cost:** Technology-dependent.

Program Strategy (% of budget):[1]

- Research and Development – 100%
- Market Transformation – 0%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Technology Roadmaps and New and Innovative R&D* (internal BTS document).

Residential Buildings

Residential Buildings R&D

Residential Buildings Integration Decision Unit

Program Objective:[1]

The Residential Building R&D program consolidates the formerly separate systems engineering programs of Building America, Industrialized Housing, Passive Solar Buildings, and Indoor Air Quality programs and existing building research into a comprehensive program to accelerate the introduction of highly efficient building technologies and practices through R&D of advanced systems for production builders.

Long-Term Goal:[1]

The long-term goal of the program is to develop advanced systems to improve the energy performance of over 300,000 of the 1 million homes that will be built in 2010. The performance increase will allow the homes to use 50% less energy for space conditioning and water heating than typical homes built in 1993.

Market Segment:

Performance Objective:[2]

- **Displaced Technology:** Current design/building practices.
- **Performance target:** 50% load reduction in space heating and cooling and water heating by 2010.

Target Market[1]

- **Market Description:** New single-family, multifamily, and manufactured housing units with over $25,000 annual income in all climate zones. Primarily new single-family homes, multifamily infill, HUD code homes, and small commercial buildings. Existing homes are to benefit from new technologies and improved construction practices developed for new homes.
- **Size of Market:** 1.4 million new housing units built each year. About 31.1 million existing households have annual incomes from $25,000 to $50,000. (The Weatherization program targets the lower-income households). These homes account for 52,165 million sq ft of floor space and use 3.19 quadrillion Btu and are primarily owner occupied.
- **Market Introduction:** 1997.[2]
- **Market Penetration Goal:**[3] See table below.

Residential Buildings R&D

Program Type:
Whole Building

Target Market:
New single-family, multifamily, and manufactured housing units with >$25,000/yr income in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
% load reduction

Modeling Tool:
BESET

Program Manager:
George James/Jon Stone

Website:
http://www.eren.doe.gov/building/building_america/

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.1	1.1	8.6	19.9

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.003	.018	.134	.322

Consumer Cost Savings (million $)

2002	2005	2010	2020
1	8	65	153

Market Penetration Curve: FY 2002 Estimate (actual numbers, previous years)		
Year	# Builders	# Homes
2001	38	3,600
2002	48	7,200
2003	60	14,400
2004	76	25,200
2005	96	44,100
2006	121	77,175
2007	152	111,904
2008	192	156,665
2009	242	203,665
2010	305	254,581
2011	384	305,497
2012	484	351,322
2013	610	386,454
2014	769	417,370
2015	969	446,586
2016	1,220	473,381
2017	1,538	497,050
2018	1,938	516,933
2019	2,441	532,440
2020	3,076	543,089

Methodology

For any one year, energy savings are calculated by multiplying the number of homes built with Building America techniques that year times the percent savings per home. Added to this are the energy savings, in that year, for Building America homes built in previous years (within the analysis period, any savings resulting from homes built prior to 2002 are not included).

Non-Energy Benefits:[1]

Consumer savings of $148 million by 2010; improved comfort, durability, and occupant health from better indoor air quality; and reduced onsite generated waste, better sustainability, and reduced maintenance.

Program/Technology Consumer Costs:

- **Cost of Conventional Technology** (average price per household [$/household):
  - Single family: $126,700/household
  - Multifamily: $74,900/household
  - Manufactured home: $41,100/household.

Program Strategy (% of budget):[1]

- Research and Development – 90%
- Market Transformation – 10%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget – *Data Bucket Template Residential Building Integration R&D* (internal BTS document).

(2) *FY 2001 GPRA Program Characterization* (internal document).

(3) Based on Impacts spreadsheet developed by Ren Anderson, August 10, 2000.

Residential Building Codes

Residential Buildings Integration Decision Unit

Program Objective:[1]

The Residential Building Codes program improves the energy efficiency of new residential buildings and additions and alterations to existing buildings. The objective will be accomplished by improving the energy-efficiency provisions of building codes and applicable standards that affect residential construction and by providing technical assistance for implementing those codes and standards.

Long-Term Goal:[1]

The program's long-term goal for applicable residential building codes is to incorporate the most technologically feasible, economically justified energy conservation measures. Another goal is to provide state and local governments with the needed technical tools and information for adopting, using, and enforcing efficient building codes for residential construction. These goals can be quantified in terms of the percentage improvements in efficiency in existing residential building codes, the number of jurisdictions that adopt and successfully implement these codes, the number of new houses built in compliance with the new code, and the number of renovations and additions to existing buildings complying with code.

Market Segment:

Target Market[1]

- **Market Description:** New residential buildings that are generally three stories or less in height (taller buildings fall under the commercial buildings program) and additions and alterations to existing buildings. The program can affect residences' major energy end uses: heating, cooling, and water heating and possibly lighting energy in the near future. All areas of the country are affected because the model building codes and standards cover all climate zones. Household income is not a discrimination of the target market because building codes cover housing at all costs and income levels. Energy-efficiency improvements via codes have repeatedly demonstrated a net positive cash flow to the new home buyer within five years, thus actually improving household income.
- **Size of Market:** About 1.4 million building permits were issued last year, over a million for single-family dwellings. Although not all jurisdictions currently have energy-efficiency building codes in place, about

Residential Building Codes

Program Type:
Information/Education

Target Market:
New residential buildings in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
% load reduction

Modeling Tool:
Spreadsheet

Program Manager:
Steve Walder

Website:
http://www.eren.doe.gov/buildings/codes_standards/bldgstds.htm

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.1	1.2	8.7	32.5

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.002	.020	.136	.521

Consumer Cost Savings (million $)

2002	2005	2010	2020
1	9	65	247

half of all new residential construction are conservatively estimated to come under building code requirements. Also, consumers spend several billion dollars a year remodeling and renovating private residences, half of which could presently be covered by an energy code. One market not currently covered by codes is manufactured homes, which fall under HUD's jurisdiction and are governed by HUD regulations.

Methodology

The program's impact is primarily through two avenues: 1) developing and supporting code changes to improve energy efficiency in residential structures, and 2) developing tools that can ease the adoption of new codes, and through their use, support improvements in compliance and enforcement of new code provisions.

Estimated Savings Per Household:

DOE has not established estimated code impacts, which may change given review of proposed activities. Because specific code changes are not identified, code improvements are uncertain. The FY 2001 extended outlook was based on a modest 1% reduction in cooling and heating loads in 2010, 2015, and 2025 from a 1995 Model Energy Code (now IECC) baseline. While no specific code changes to achieve this are identified, this level of change appears achievable based on past program experience.

Energy savings from improvements in adopting and complying with new codes are based on modeling energy improvements in the IECC over existing 1995 MEC efficiency levels. States are assumed to have complied with the 1995 MEC. The following is also assumed to occur by 2010:

- States that have adopted some form of the MEC eventually will adopt some form of the IECC requirements (29 states, ~31.7% of new construction).
- Specific states that are non-MEC compliant will potentially adopt a national code like the IECC (14 states, ~26.3% of new construction).
- Specific states that currently don't have mandatory residential energy codes will likely adopt an energy code in the near future (6 states, ~8.4% of new construction).

Compliance rates are based on average compliance rates for residential codes, in general estimated at 43% in 2000 and climbing to 65% in 2010 and 75% in 2020. Compliance is increased through better familiarity with the code over time, simplifications to the code while maintaining stringency, and the availability and increased use of compliance tools by builders and enforcement officials.

BTS has not provided any specific estimates for potential energy savings from residential codes. The above methodology is consistent with the methodology used in the GPRA FY 2001 estimates. Energy-efficiency improvements through updates to energy codes are PNNL conjecture and should be run through the Residential BRS Team. Note, no task for residential technical assistance was defined separately from the residential codes task. Currently, all savings estimated for new codes are captured by this Residential Buildings Codes program estimate.

Non-Energy Benefits:[1]

Lower utility bills, improved indoor comfort, lower home maintenance and repair activities, and reduced pollution from burning fossil fuels and generating electricity, which improves air quality and mitigates the negative impacts of global warming.

Program Strategy (% of budget):[1]

- Research and Development – 0%
- Market Transformation – 0%
- Codes and Standards – 100%.

Sources:

(1) FY 2002 Budget — *Data Bucket Report for Residential Building Integration R&D Program* (internal BTS document).

Commercial Buildings

Commercial Buildings R&D

Commercial Buildings Integration Decision Unit

Program Objective:

The Commercial Buildings R&D program develops and demonstrates advanced technologies, controls, and equipment in collaboration with the design and construction community. The program focuses on advancing integrated technologies and practices to optimize whole-building energy performance. The program reduces energy use in commercial and multifamily buildings by promoting practices that help ensure the industry constructs buildings as designed and operates them at or near the optimum level of performance.

Long-Term Goal:

The program's long-term goal is to improve by 30% the energy efficiency of the nation's new commercial buildings and existing buildings by 20% by 2010 compared with 1996.

Market Segment:

Performance Objective:

- **Displaced Technology:** Conventional design/ building practices.
- **Performance Target:** Reduce heating and cooling loads by 30% in new construction and by 20% in existing units compared with 1996.

Target Market[1]

- **Market Description:** Commercial buildings that the program's research products are most likely to impact; includes all commercial buildings *except* those using very low amounts of energy (<10% of average building consumption) and those having very low energy-use intensities (<50% of the average energy-use intensity).
- **Market Introduction:** 1996 (inception date of program is 1977).
- **Market Penetration Goal:** To penetrate 5% of all multifamily existing residential buildings and 5% of targeted existing commercial buildings by 2020. In addition, penetrate 5% of new residential and targeted commercial buildings in combination with the Analysis Tools and Design Strategies program.

Non-Energy Benefits:

Reduced operation and maintenance expenses, improved indoor environmental quality, increased prop-

Commercial Buildings R&D

Program Type:
Whole Building

Target Market:
New and existing commercial and residential multifamily units in all climate zones

End Uses:
Heating and cooling

Unit of Measurement:
% load reduction

Modeling Tool:
BESET

Program Manager:
Dru Crawley

Website:
http://www.eren.doe.gov/buildings/high performance

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.0	0.0	1.8	8.8

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.000	.000	.030	.148

Consumer Cost Savings (million $)

2002	2005	2010	2020
0	0	13	65

erty asset value, higher tenant satisfaction and retention rates, and increased product sales.

Program Strategy (% of budget):

- Research and Development – 90%; The bulk of funding is research focused on high- performance building techniques, fault detection and diagnostics, indoor environmental quality, building commissioning, and integrated building systems.
- Market Transformation – 10%; Small initiatives were established with the Building America and Rebuild America programs to incorporate high-performance building research into their deployment activities to create direct linkages between the separate R&D and deployment programs, which are focused on the same target markets.
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget – *Bucket Report for Commercial Buildings Integration R&D Program* (internal BTS document).

Commercial Buildings Codes

Commercial Buildings Integration Decision Unit

Program Objective:[1]

The Commercial Buildings Codes program promotes energy efficiency by promulgating federal energy codes while working with model code groups to upgrade building codes and standards that state and local jurisdictions can adopt and that are applicable to all new commercial and high-rise residential buildings, permitted renovations, and additions. This program targets all new commercial buildings, with federal construction representing about 3% of all new construction.

Long-Term Goal:[1]

The program's long-term goal is to reduce total energy use by 30% to 35% in all new commercial building construction by the year 2010. Energy use will be reduced by the widespread adoption of building energy codes by all states and U.S. jurisdictions. The program is also establishing an educational library consisting of manuals, software, and training support for both voluntary commercial and federal commercial energy-efficiency codes.

Market Segment:

Target Market

- **Market Description:** All new commercial and multifamily high-rise buildings and all permitted additions and renovations to those buildings.
- **Size of Market:** About 4.7 million buildings representing 62.9 billion sq ft of floor space, consuming about 7.7 quad of energy onsite and costing $85.2 billion annually. The federal sector represents about 2.3% overall of new commercial building construction.

Energy savings from this program and the related Technical Assistance for Codes result from basic improvements in overall energy efficiency of commercial buildings. The present funding method channels funding for conducting research activities for new codes and for developing compliance tools – primarily for existing codes – through BTS's Building Research and Standards area. Funding for the Training and Technical Assistance for state building energy codes (related primarily to existing codes) is channeled through BTS Building Technology Assistance area. Benefits cannot be clearly allocated to either area.

Commercial Buildings Codes

Program Type:
Information/Education

Target Market:
New commercial buildings in all climate zones

End Uses:
All end uses, all fuel types

Unit of Measurement:
% load reduction

Modeling Tool:
Spreadsheet

Program Manager:
Ron Majette

Website:
http://www.eren.doe.gov/buildings/codes_standards/bldgstds.htm

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.3	3.5	7.8	31.9

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.006	.065	.130	.562

Consumer Cost Savings (million $)

2002	2005	2010	2020
2	23	56	242

Barring future guidance from DOE, benefits for FY 2002 were assumed to be allocated according to ratio of actual funding levels. The description of the methodology below also pertains to Technical Assistance for Codes.

The program's impact is primarily through two avenues: 1) developing and supporting standard/code changes to improve energy efficiency in commercial building structures and 2) developing tools that can ease the adoption of new codes, and through their use, support improvements in compliance and enforcement of code provisions. Tools take the form of code compliance software, computer-based training tools for building energy codes, and non-computer-based code implementation tools.

Changes to building standards and codes are primarily supported by research efforts to review existing codes and specific targeted areas of building energy use and the adoption of code modifications that promote cost-effective reductions in these energy use areas. The research work has typically taken place on three fronts: support for ASHRAE/IES 90.1, support for developing federal building codes, and support for developing the IECC.

Code improvement energy savings are based on an estimated percentage reduction in whole-building energy-use intensity from code changes affecting lighting, cooling, and space heating loads over base code levels. Building simulation estimates of code-to-code energy savings between ASHRAE 90.1-1989,[2] used as a proxy for existing U.S. building codes, and proposed code versions of 90.1-1999,[3] have influenced the acceptance of 90.1 revisions. Near-term increases in energy efficiency are expected to come less from increases in the stringency of the voluntary standard and more from a larger fraction of buildings.

Energy savings from improvements in adoption and compliance with new codes are based on estimates of target improvements in new codes in comparison with an ASHRAE 90.1-1999 baseline level. In the past, estimates for changes to equipment efficiency have not been used to establish the code-to-code energy savings because these savings were to be reflected in the separate EPAct Standards Program. The following is assumed to occur by 2010:

- States that have adopted some form of ASHRAE Standard 90.1-1989[2] by reference will adopt some form of the 90.1-1999 or IECC 2001 requirements (24 states, ~31.2% of new commercial construction).
- Specific states that reference noncompliant national codes (chiefly ASHRAE Standard 90a-1980)[3] will adopt a commercial code equivalent to 90.1-1999 to meet requirements of EPAct (11 states, ~18.6% of new construction).
- States that have state-developed codes that presently exceed 90.1-1989 will develop codes that exceed 90.1-2002, 90.1-2005, and 90.1-2008 (6 states, ~26.8% of new construction).

Compliance rates are based on an assumed average compliance rate of 43% in 2000, climbing to 80% in 2010. Compliance represents percent achievement of the nominal energy savings differential estimated between base 90.1-1989 code[2] and new codes.

Non-Energy Benefits:

Improved environment and more comfortable buildings.

Sources:

(1) FY 2002 Budget – *Data Bucket Report for Commercial Building Codes Program* (internal BTS document).

(2) ASHRAE Standard 90.1-1989, "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings."

(3) ASHRAE Standard 90a-1980, "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings."

Equipment, Materials and Tools

Lighting R&D

Equipment, Materials, and Tools Decision Unit

Program Objective[1]:

The Lighting R&D program develops and accelerates the introduction of advanced lighting technologies. A new initiative in this program, solid-state lighting, will foster the introduction of solid-state lighting and will seek to achieve the following for lighting:

- Significantly greater efficiency than conventional sources
- Easily integrated into building systems of the future
- Able to provide the appropriate color and intensity for any application
- Lasting for 20,000 to 100,000 hours
- Able to readily supplement natural sunlight.

Long-Term Goal:[1]

The program's long-term goal is to reduce energy use for lighting by 50% by 2020.

Market Segment

Target Market

- **Market Description:** All commercial buildings.
- **Size of Market:** The commercial building stock was about 63 billion sq ft in 2000, and lighting uses 26% (3.9 quad) of the primary energy in commercial buildings.

Methodology

The energy savings from the lighting program was generally based on the BTS Program Manager's judgment on the probable penetration of specific lighting technologies. However, the resulting savings are formally calculated from the NEMS commercial energy module. The capital costs of the technologies are adjusted to achieve approximate congruence with the external penetration assumptions.

For the solid-state lighting initiative, key assumptions concerning the likely dates of introduction and the expected efficacies were influenced by a recent white paper, "The Case for a National Research Program on Semiconductor Lighting."[2] This paper was prepared by staff from Hewlett-Packard and Sandia National Laboratories and was presented in late 1999 at an industry forum.

As was done in FY 2001, the NEMS model was used to project savings from the lighting program. The current

Lighting R&D

Program Type:
Equipment Efficiency

Target Market:
Potentially all sectors and all climate zones (primarily impacts commercial sectors and higher-income residential buildings)

End Uses:
Lighting and electricity

Unit of Measurement:
Lumens/Watt

Modeling Tool:
NEMS

Program Manager:
Ron Lewis

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FY 2002 Benefits

Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.0	2.1	63.2	330.8

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.000	.039	1.080	5.991

Consumer Cost Savings (million $)

2002	2005	2010	2020
0	14	481	2,636

model allows the BTS technology to compete with a wide variety of technologies. The issue is complicated by EIA's use of functions to represent declining costs of new technologies. Accordingly, the same general approach was followed as for the FY 2001 effort in which costs of the BTS technologies were adjusted to achieve some congruence with the expected penetration rates. If some reasonable basis for future costs can be developed, these costs can be put into the model to determine economic viability.

For the FY 2002 estimates, the lighting estimates were based on NEMS projections that included two technologies supported by BTS: 1) solid-state lighting and 2) the two-photon phosphor lamp. In NEMS, each lighting technology is characterized by an efficacy level (lumens/watt), a capital cost ($/1000 lumens), and an annual cost of lamps ($/1000 lumens). For new technologies, the capital costs can be reduced along a logistic-shaped curve.

For solid-state lighting, Table 1 summarizes the cost inputs for some of the key lighting technologies used in NEMS for FY 2002. NEMS divides the commercial lighting market into four major groups: 1) incandescent (point source), 2) 4-foot fluorescent, 3) 8-foot fluorescent, and 4) high-intensity point source (outdoor lighting). Solid-state lighting was assumed to penetrate the first three market groupings; the two-photon phosphor lamp was assumed to compete only with the fluorescent lighting groups. Table 2 summarizes the cost inputs for the two-photon phosphor program.

Given these costs, NEMS chooses among these technologies for each building type in each census division. For each combination, the market was assumed to consist of various segments, each with a different discount rate. Within each segment, a lighting technology was selected on the basis of minimum annualized cost.

Table 3 summarizes the results of the market shares generated by NEMS for FY 2002. The market shares relate to the sales of new and replacement equipment in the year shown. Given the assumed 12-year life for lighting equipment, the market shares in the existing stock would be much lower than the shares shown in the table.

Table 1. Solid-State Lighting Cost and Efficiency Assumptions: FY 2002 GPRA

Lighting Technology	Efficacy (lumen/ watt)	Capital Cost, 2010 ($/1000 lumen)	Capital Cost, 2020 ($/1000 lumen)	Annual Operating Cost ($/1000 lumens)
Incandescent				
Incandescent	15.6	34.02	34.02	10.72
Compact Fluorescent Light	66.7	37.74	36.79	6.21
Solid-State Lighting, 2005	40	40.00	40.00	0.51
Solid-State Lighting, 2010	60	30.00	30.00	0.51
Solid-State Lighting, 2015	80	NA	25.00	25.00
4-Foot Fluorescent				
F32T8 Electronic	84.2	23.64	23.46	0.51
Solid-state Lighting, 2010	60	25.00	25.00	0.51
Solid-state Lighting, 2015	80	NA	20.00	0.51
8-Ft Fluorescent				
F96T12 Electronic	73.9	7.49	7.49	7.49
Solid-state Lighting, 2010	60	10.00	10.00	0.39
Solid-state Lighting, 2015	80	NA	7.00	0.39

NA = Not available.

Table 2. Two-Photon Phosphor Cost and Efficiency Assumptions: FY 2002 GPRA

Lighting Technology	Efficacy (lumens/ watt)	Capital Cost, 2010 ($/1000 lumen)	Capital Cost, 2020 ($/1000 lumen)	Annual Operating Cost ($/1000 lumens)
4-Foot Fluorescent				
F32T8 Electronic	84.2	23.64	23.46	0.51
Two-photon phosphor (2010 introduction)	160	26.00	17.60	0.51

Non-Energy Benefits:

Helps maintain U.S. semi-conductor leadership, develops U.S. leadership in lighting

Table 3. Shares of Installed Lighting Capacity by Major TechnologyñNEMS projections				
Solid State Lighting				
Incandescent	**2005**	**2010**	**2015**	**2020**
Incandescent 1170 Lumens, 75 watt	0.38	0.26	0.14	0.08
Compact Fluorescent Light 786 Lumens, 14.6 Watts ----> 18 watt 1200 lumen	0.44	0.28	0.17	0.11
Solid-state Lightingñ2005 Intro (40 watt/ lumen)	0.07	0.32	0.44	0.33
Solid-state Lightingñ2010 Intro (60 watt/ lumen)		0.08	0.13	0.10
Solid-state Lightingñ2015 Intro (80 watt/ lumen)			0.08	0.37
4-Foot Fluorescent				
Standard Magnetic	0.16	0.10	0.07	0.05
Efficient Magnetic	0.14	0.09	0.06	0.04
F32T8 ñ Magnetic	0.16	0.10	0.06	0.04
F32T8 ñ Electronic	0.24	0.40	0.45	0.30
F32T8 ñ Electronicñ Reflector	0.22	0.21	0.19	0.12
Solid-state (2015 intro-duction, 80 watt/lumen)	0	0	0.09	0.40
8-Foot Fluorescent				
Standard Magnetic	0.15	0.10	0.06	0.04
Efficient MagneticñEnergy Saver	0.10	0.06	0.04	0.03
ElectronicñEnergy Saver	0.35	0.46	0.48	0.32
ElectronicñHigh Output	0.20	0.24	0.27	0.27
Solid-state (2015 introduction)			0.06	0.29
4-Foot Fluorescent				
Standard Magnetic	0.16	0.10	0.07	0.04
Efficient Magnetic	0.14	0.09	0.06	0.04
F32T8 - Magnetic	0.16	0.10	0.06	0.04
F32T8 - Electronic	0.24	0.40	0.52	0.56
F32T8 - Electronic ñ Reflector	0.22	0.21	0.18	0.12
8-Foot Fluorescent				
Standard Magnetic	0.15	0.10	0.06	0.04
Efficient MagneticñEnergy Saver	0.10	0.06	0.04	0.03
ElectronicñEnergy Saver	0.35	0.46	0.51	0.50
ElectronicñHigh Output	0.20	0.24	0.26	0.26

technology, reduces pollution and contributes to U.S. climate change goals, and improves U.S. productivity from better lighting in work environments.

Program Strategy (% of budget):

- Research and Development – 80%
- Market Transformation – 20%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Lighting R&D Program* (internal BTS document).

(2) Haitz, R., and F. Kish. October 6, 1999. "The Case for a National Research Program on Semiconductor Lighting." Sandia National Laboratories. White paper presented at the 1999 Optoelectronics Industry Development Association forum in Washington D.C.

Space Conditioning and Refrigeration R&D

Equipment, Materials, and Tools Decision Unit

Program Objective:[1]

The Space Conditioning and Refrigeration R&D program develops and promotes the use of commercial food display and storage technologies that use less energy and less refrigerant. Water-heating activities center on developing low-cost, high-reliability heat pump water heater concepts. The technology supported under this program is intended to reduce the energy losses incurred in transferring heating or cooling from the conditioning unit(s) (e.g., heat pump, furnace, and air conditioner) to the conditioned space.

Long-Term Goal: [1]

The program's long-term goal is to reduce energy for building HVAC and refrigeration equipment over the next 15 to 20 years. Specific goals include reducing energy use for electric water heating by at least 50%; building space heating and cooling by 20% to 25%, respectively; and supermarket refrigeration and HVAC energy use by at least 15%, while reducing the level of refrigerant needed.

Market Segment:

Target Market

- **Market Description:**[1] Commercial refrigeration, a broad classification of building equipment that collectively consumes about one quad of energy annually in the United States. Supermarkets consume about one-third of the energy of commercial refrigeration, with self-contained refrigeration equipment consuming about two-thirds of that energy. Residential applications include air conditioners, heat pumps, heat pump water heaters, and thermal distribution systems.
- **Size of Market:** [1] Commercial refrigeration markets include about 30,000 large supermarkets and 100,000 convenience stores. Other markets include hospitals, large institutional buildings, and restaurants. Residential markets include space conditioning and water heating in about 1.2 million annual new and 72.5 million existing single-family homes.

Methodology

For FY 2002, three technologies were modeled: residential HVAC distribution systems, advanced electric heat pump water heaters, and commercial refrigeration.

Space Conditioning and Refrigeration R&d

Program Type:
Equipment Efficiency

Target Market:
Refrigeration: Commercial food sales in all climate zones.
Heat pump water heater and HVAC distribution: Residential.

End Uses:
Heating and cooling and water heating

Unit of Measurement:
Refrigeration: kWh/year
Heat Pump Water Heater: efficiency/unit
HVAC Dist: % load reduction

Modeling Tool:
Refrigeration and heat pump water heater: Spreadsheet
HVAC Dist: BESET

Program Manager:
Esher Kweller

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FY 2002 Benefits

Primary Energy Savings (TBtu)

2002	2005	2010	2020
5.6	18.5	46.3	93.3

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.106	.337	.781	1.644

Consumer Cost Savings (million $)

2002	2005	2010	2020
35	119	349	740

Space Conditioning and Refrigeration R&D

Equipment, Materials, and Tools Decision Unit

Residential HVAC Distribution Systems

This technology will reduce the energy liabilities of residential duct work.

Performance Objective:

- **Displaced Technology:** Current duct work.
- **Performance Target:** 20% reduction in heating and cooling loads.

Market Penetration:

- **Market Introduction:** 2002.
- **Market Penetration Goal:** 20% of new single-family units by 2020.

Advanced Electric Heat Pump Water Heaters

This technology involves the further development of a heat pump water heater with a drop-in replacement capability. This improvement was assumed to increase sales of the heat pump water heater characterized in the Appliances and Emerging Technologies R&D program by 20% starting in 2007.

Performance Objective:

- **Displaced Technology:** Current water heater technology.
- **Performance Target:** 2.47 energy factor.

Market Penetration:

- **Target Market:** Residential.
- **Market Introduction:** 2007.
- **Market Penetration Goal:** A 20% increase in sales of heat pump hot water heaters.

Commercial Refrigeration

This program has been modeled as an advanced supermarket refrigeration system, which would target heating, cooling, and refrigeration end-use loads in the commercial food sales sector. These end uses comprise about 67% of total electrical end-use energy consumption and about 61% of total natural gas end-use energy consumption.

To calculate the energy savings for this program, the overall reduction in end-use energy consumption was applied to the estimated consumption per square foot within food sales buildings. This per-square-foot energy-savings level was aggregated to a program total based on a forecast of square feet of food sales buildings and an estimated market penetration curve. Specific input data are outlined below.

Performance Objective:

- **Displaced Technology:** Conventional refrigeration equipment in food sales buildings.
- **Performance Target:** Reduced energy for building HVAC and refrigeration equipment over the next 15 to 20 years, specifically, reduced energy use of at least 15% for supermarket refrigeration and HVAC energy use while reducing refrigerant needed.

Market Penetration:

- **Target Market:** All commercial food sales buildings.
- **Market Introduction:** 2001.
- **Market Penetration Goal:** 95% penetration by 2020 and 100% by 2030.

Non-Energy Benefits:

Reduced carbon emissions, economic benefits to private sector, reduced pollution from leaking refrigerant, and improved indoor air quality from better humidity control.

Program Strategy (% of budget): [1]

- Research and Development – 100%
- Market Transformation – 0%
- Codes and Standards – 0%.

Sources:

(1) *FY 2002 Budget Request – Data Bucket Report for Space Conditioning and Refrigeration: Refrigeration Program* (internal BTS document).

Appliances and Emerging Technologies

Equipment, Materials, and Tools Decision Unit

Program Objective: [1]

The Appliances and Emerging Technologies R&D program assists manufacturers and utilities in the commercializing highly efficient appliances and equipment with the following:

- Technology procurement to bring new products to market (late developmental work), which can bridge the gap between traditional R&D and mainstream deployment.
- For emerging technology products and Energy Star products with very low market penetration, independent third-party evaluation and verification of highly efficient products using field studies and demonstrations to increase market share.
- R&D on appliances that are not covered by other programs but that offer significant energy-savings potential.

The program also provides technical assistance and R&D on international issues and monitors international emerging technologies.

Long-Term Goals: [1]

The program's long-term goal is to establish a track record of commercializing highly efficient products that become entrenched in the mainstream market and that become the basis for other mechanisms, such as Energy Star or minimum efficiency standards.

Market Segment:

Target Market

- **Market Description:** Residential and commercial building products, with emphasis on appliances and water heating.
- **Size of Market:** Depends on the various equipment:
  - **Heat Pump Water Heater:** About 13.6 million existing homes of the 36 million homes with electric resistance water heaters and about 40% of new homes. Limited, but initial market, for light commercial.
  - **Condensing Gas Water Heaters:** About 20 million existing homes of the >60 million homes potential and about 40% of new homes.
  - **Dryers:** About 57 million existing homes and about 80% of new dryer sales.

Appliances and Emerging Technologies R&D

Program Type:
Equipment Efficiency

Target Market:
All sectors, all climate zones

End Uses:
Water heaters, lighting, dryers, and space cooling

Unit of Measurement:
Efficiency of specific equipment type

Modeling Tool:
NEMS and Spreadsheets

Program Manager:
Jim Brodrick

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
5.1	12.9	30.8	78.3

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.098	.236	.514	1.346

Consumer Cost Savings (million $)

2002	2005	2010	2020
36	94	258	662

Methodology

Several of the technologies were modeled using NEMS. The key inputs and outputs from the model are described below.

Technology Assumptions

Residential Can Lights

- **Market Introduction:** 2001.
- **Performance Target:** 75% energy savings (baseline 60-W incandescent relative to 15-W compact fluorescent light). Assumes 3 hr/day operation (49 kWh/fixture/yr).
- **Size of Market:** Projected sales of 21.8 million incandescent fixtures in FY 2002.
- **Sales Target:** 30% of sales in 2020.

This program was modeled in a spreadsheet using the above information.

Subcompact Fluorescent Lights

- **Sales Target:** 1.5 million sales/year in FY 2001, 2002, and 2003.
- **Performance Target:** Assumed efficacy of 70 lumens per watt.
- **Installed Cost:** $5 /compact fluorescent light.

This program was modeled in a spreadsheet using the above information.

Rooftop Air Conditioning

- **Market Introduction:** 2004.
- **Performance Target:** 10% increase in efficiency.
- **Sales Target:** 10% of sales.

This program was modeled in a spreadsheet using the above information.

Dryers

- **Market Introduction:** 2005.
- **Performance Target:** 40% efficiency improvement.
- **Installed Cost:** $75 over conventional.

Table 1 shows the NEMS inputs for electric clothes dryers, with the assumptions highlighted for the BTS-sponsored advanced dryer. While the equipment types are not identified by name, the table illustrates the range of technologies competed within NEMS. The EIA base case includes two dryer technologies, but with second unit less than 10% more efficient than the base unit. The BTS program is assumed to introduce an advanced technology with an incremental efficiency improvement of 40% over the base unit.

Table 1. NEMS Residential Model Inputs for Advanced Electric Clothes Dryers*

Equip Model Type	Last Year Avail	Effic.	Installed Cost	Logit Model Para: Beta1	Logit Model Para: Beta2	Implied Discount Rate
1	2020	3.01	$333	-0.09	-0.1	0.9
2	2020	3.21	$383	-0.09	-0.1	0.9
3A	2020	4.21	$393	-0.09	-0.1	0.9
3B	2020	4.21	$383	-0.09	-0.1	0.9
3C	2020	4.21	$373	-0.09	-0.1	0.9

Highlighted cells indicate BTS programs.
* Models 3B and 3C introduced in 2010 and 2015.

The initial cost differential for the NEMS simulation was assumed to be $60, slightly lower than the program target. (The NEMS model has an very high discount rate for electric dryers and, in this particular case, the presence of a radically new technology would possibly lower that effective rate. Instead of adjusting the discount rate, the equipment cost differential was reduced.) In 2010 and 2015, the cost differential is lowered further to spur increases in the market share of this technology.

Table 2 roughly indicates the market shares yielded by NEMS for the advanced electric dryers. In the standard version of the NEMS model, no single table summarized the national shares of sales by technology for dryers. Thus, the ranges reflect the results for the various market segments defined by census division

Table 2. Market Share of Sales for Advanced Electric Dryer

Year	In All Housing Units (%)
2005	3-5
2010	8-10
2020	15-20

and housing type. (For the water heater results shown in Tables 3 and 4, special coding was added to the model to derive national shares by technology.)

Heat Pump Water Heater

- **Market Introduction:** 2005.
- **Performance Target:** 2.47 energy factor (demonstrated).
- **Sales Target:** More aggressive sales target by 2015 (currently 6%), possibly 10% (building codes expected to help by excluding electric resistance water heating, as will be case in California).
- **Installed Cost:** Initial installation cost of $700, decreasing to $650 in 2010.

The heat pump water heater and residential gas condensing water heater programs were modeled with NEMS. Table 3 shows the NEMS inputs for electric water heaters, with the BTS-sponsored heat pump water heater input assumptions highlighted. While the equipment types are not identified by name, the table illustrates the range of technologies competed within NEMS. Note that EIA assumes several levels of resistance water heaters with efficiencies ranging from 0.86 to 0.96. The very high-efficiency water heaters in the EIA base case are very costly.

Table 3. NEMS Residential Model Inputs for High-Efficiency Heat Pump Water Heater

Equip. Model Type	Last Year Avail	Effic.	Installed Cost	Logit Model Para: Beta1	Logit Model Para: Beta2	Implied Discount Rate
7	2020	0.86	$350	-0.01619	-0.01952	0.83
8	2020	0.88	$350	-0.01619	-0.01952	0.83
9	2020	0.95	$575	-0.01619	-0.01952	0.83
10	2020	2.60	$1,025	-0.01619	-0.01952	0.83
11	2020	2.00	$2,600	-0.01619	-0.01952	0.83
12	2020	0.89	$350	-0.01619	-0.01952	0.83
13	2020	0.96	$475	-0.01619	-0.01952	0.83
14	2020	2.47	$700	-0.01619	-0.01952	0.83
15	2020	0.90	$400	-0.01619	-0.01952	0.83
16	2020	0.96	$425	-0.01619	-0.01952	0.83
17	2020	2.47	$650	-0.01619	-0.01952	0.83

Highlighted cells indicate BTS programs.

Table 4 shows the penetration of the BTS-sponsored heat pump water heater for sales to new homes and for replacement of existing electric water heaters. In the first few years of the programs, NEMS projected the market share to be ~1%. After the assumed $50 cost reduction in 2010, the market share increases to a little more than 3%. These low shares are largely attributed to the high discount rate used in NEMS. As shown in the last column of Table 4, the value of the discount rate for electric water heaters was assumed to be over 80%. Thus, in spite of the performance differential for the heat pump unit, the higher first cost was assumed to be a large barrier in promoting widespread adoption of this technology.

Table 4. NEMS-Generated Penetration Rates for High-Efficiency Heat Pump Water Heaters

Year	In New Housing Units	Fraction of Electric WH	Replace. Units	Fraction of Electric WH
2005	7,325	0.011	26,435	0.012
2006	7,374	0.011	27,020	0.012
2007	7,461	0.011	27,343	0.012
2008	7,345	0.011	27,507	0.012
2009	7,142	0.010	27,861	0.012
2010	22,773	0.033	90,881	0.037
2015	18,268	0.026	73,876	0.029
2020	17,515	0.025	74,509	0.028

Several other points should be made with regard to the model-generated penetrations shown in Table 4. NEMS has no technology diffusion algorithm that will produce a gradual increase in market shares without any change in cost and performance. Thus, the market shares from 2005 through 2010 are virtually the same. It can be argued that the model provides an average penetration that yields the same level of total sales as would an s-shaped penetration curve. A second point relates to the decline in the shares in the out years, 2015 and 2020. This result stems entirely from the

reductions in cost assumed for the resistance water heater assumed in the base case.

Table 5 shows the NEMS inputs for gas water heaters, with the input assumptions highlighted for the BTS-sponsored condensing water heaters. Again, while the equipment types are not identified by name, the table illustrates the range of technologies competed within NEMS. Note that EIA assumes several levels of gas water heaters (noncondensing) with efficiencies ranging from 0.54 to 0.70. With an efficiency of 0.86, the condensing water heaters in the EIA base case are very costly.

Table 5. NEMS-Generated Inputs for Gas Water Heaters

Equip Model Type	Last Year Avail	Effic.	Installed Cost	Logit Model Para: Beta1	Logit Model Para: Beta2	Implied Discount Rate
1	2020	0.54	$340	-0.05393	-0.1136	0.47
2	2020	0.58	$370	-0.05393	-0.1136	0.47
3	2004	0.6	$400	-0.05393	-0.1136	0.47
3	2020	0.6	$375	-0.05393	-0.1136	0.47
4	2004	0.86	$2,360	-0.05393	-0.1136	0.47
4	2014	0.86	$2,000	-0.05393	-0.1136	0.47
4	2020	0.86	$1,800	-0.05393	-0.1136	0.47
5	2014	0.63	$450	-0.05393	-0.1136	0.47
5	2020	0.63	$425	-0.05393	-0.1136	0.47
6	2020	0.7	$500	-0.05393	-0.1136	0.47
26	2020	0.8	$500	-0.05393	-0.1136	0.47
27	2020	0.8	$475	-0.05393	-0.1136	0.47

Highlighted cells indicate BTS programs.

Residential Gas Condensing Water Heater

- **Market Introduction:** 2002.
- **Performance Target:** Energy factor of 0.80.
- **Penetration Target:** 9% to 10% by 2020.
- **Installed Cost:** Assumes $350 base cost; new water heating will have an incremental cost of $150 to $200.

Table 6 shows the penetration of the BTS-sponsored condensing gas water heaters for sales to new homes and for replacements of existing gas water heaters. In the first few years of the programs, NEMS projected the market share to be ~2%. After the assumed $25 cost reduction in 2010, the market share increases to about 6% in new homes and over 7% for replacement units. These low shares are largely attributed to the high discount rate used in NEMS. As the last column of Table 4 shows, the value of the discount rate for gas water heaters was assumed to be nearly 50%. The behavior of the predicted shares for this technology is similar to that of the heat pump water heater. The shares fall slightly over the full forecast period as the cost and performance of competing (noncondensing) water heaters improve.

Table 6. Sales Penetration for Condensing Gas Water Heater

Year	In New Housing Units	Fraction of Gas WH	Replace. Units	Fraction of Gas WH
2003	19,424	0.019	60,336	0.019
2004	19,481	0.019	62,811	0.020
2005	15,445	0.014	48,305	0.015
2010	60,035	0.056	234,092	0.071
2015	55,912	0.054	233,794	0.068
2020	46,945	0.046	230,349	0.059

Non-Energy Benefits:

Environmental savings, savings from water conservation devices and high-efficiency appliances. (These benefits are being better characterized and will be used to justify water/waste water utilities implementing demand-side management programs.)

Program Strategy:

- Research and Development – 50%
- Market Transformation – 50%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Appliances and Emerging Technology Program* (internal BTS document).

Building Envelope R&D: Electrochromic Windows

Equipment, Materials, and Tools Decision Unit

Program Objective: [1]

This program develops commercially viable advanced electrochromic windows using competing producers. With a focus on electrochromic research, the program's objective is to reward the marketplace for industry's investments in the research, development, and deployment of energy-efficient windows.

In an area that is less suited to national standards and that has a growing international market, significant investments are required to establish a technical basis for performance standards recognized for their scientific excellence. On this basis, the program helps develop the credible rating and certification programs and the design tools to develop and apply efficient windows. One program objective is to double the average energy efficiency of windows sold and establish universal NFRC (National Fenestration Rating Council) ratings based on credible International Standards Organization (ISO) standards.

Long-Term Goals: [1]

- **National:** Change windows from net energy loss to net energy benefits across the United States.
- **Current Energy Losses:** 3.2 quad.
- **Environmental Impact:** 64 MMtons carbon/yr.
- **Industry:** Strengthen market position of U.S. industry in global markets.
- **Owners:** Provide cost-effective savings with comfort, productivity, and amenity.

Market Segment:

Performance Objective:

- **Displaced Technology:** Conventional double-glazed, low-emissivity windows.
- **Performance Target:** Reduction in unwanted heat gains and losses and perimeter lighting. Estimated savings per building will be determined by simulating all commercial building types in all climate zones.
- Performance Parameters: See the following table.

Target Market

- **Market Description:** [1] New and existing commercial building types in all climate zones.
- **Size of Market:** About 55 million manufactured units sold each year, for residential and light commercial.

Building Envelope R&D: Electrochromic Windows

Program Type:
Envelope

Target Market:
All commercial buildings in all climate zones

End Uses:
Windows

Unit of Measurement:
% load reduction per square foot (commercial)

Modeling Tool:
NEMS

Program Manager:
Sam Taylor

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
2.7	8.0	17.8	59.9

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.052	.149	.305	1.089

Consumer Cost Savings (million $)

2002	2005	2010	2020
17	52	137	482

Building Envelope R&D: Electrochromic Windows

Equipment, Materials, and Tools Decision Unit

Parameter	Value
Maximum Shading Coefficient	0.4 (heating)
Minimum Shading Coefficient	0.1 (cooling)
U-value	0.25 Btu/h · ft^2 °F
Lighting Reduction	30% of lighting energy

- **Market Introduction:** Program began before 1977; the market introduction is targeted for the end of FY 2002 for electrochromic windows in commercial applications.
- **Market Penetration Goal:** See table below.

Rate of Penetration (% of annual sales)					
Building Type	**Vintage**	**Region**	**2005 (%)**	**2020 (%)**	**2030 (%)**
All Commercial	New	All	2	20	50
All Commercial	Existing	All	1.8	17.2	43.2

Non-Energy Benefits: (1)

Potential for reducing both utility and building peak loads, which allow for reduced HVAC requirements and thus, lower first costs, which can offset increased high-performance glazing costs. Other benefits include environmental benefits, particularly from reduced utility peak loads, comfort, and aesthetics.

Program/Technology Consumer Costs:

- **Incremental Cost of BTS Technology:** +$5/sq ft for electrochromic windows compared with conventional, double-glazed, low-emissivity windows.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Building Envelope: Windows Program* (internal BTS document).

Building Envelope R&D: Superwindows

Equipment, Materials, and Tools Decision Unit

Program Objective: [1]

The program's objective is to reward industry for its investments in the research, development, and deployment of energy efficient windows. In an area that that has a growing international market, significant investments are required to establish a technical basis for performance standards that is recognized for its scientific excellence.

On this basis, the program helps develop the credible rating and certification programs and the design tools to develop and apply efficient windows. The program is developing commercially viable advanced technologies from competing producers and providing research support to Energy Star and Efficient Window Collaborative programs. One program objective is to double the average energy efficiency of windows sold and establish universal NFRC (National Fenestration Rating Council) ratings based on credible International Standards Organization (ISO) standards.

Long-Term Goals: [1]

- **National:** Change windows from net energy loss to net energy benefits across the United States.
- **Current Energy Losses:** 3.2 quad
- **Environmental Impact:** 64 MMtons carbon/yr.
- **Industry:** Strengthen market position of U.S. industry in global markets.
- **Owners:** Provide cost-effective savings with comfort, productivity, and amenity.

Market Segment:

Performance Objective:

- **Displaced Technology:** Conventional double-glazed, low-emissivity windows with a U-value of 0.4 Btu/h · ft^2 ^{o}F and a shading coefficient of .55.
- **Performance Target:** Reduce unwanted heat gains and losses. The estimated savings per building will be determined by simulating residential buildings in all climate zones.
- **Performance Parameters:** Two superwindow technologies will be used: northern superwindows in heating dominated climates (heating-degree days >4000) and southern superwindows in cooling dominated climates (heating-degree days <4000). See the table below.

Building Envelope R&D: Superwindows

Program Type:
Envelope

Target Market:
All residential buildings, all climate zones

End Uses:
Windows

Unit of Measurement:
% load reduction per unit (residential)

Modeling Tool:
Spreadsheet

Program Manager:
Sam Taylor

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.0	10.7	52.7	254.1

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.000	.176	.839	4.089

Consumer Cost Savings (million $)

2002	2005	2010	2020
0	75	390	1885

Building Envelope R&D: Superwindows

Equipment, Materials, and Tools Decision Unit

Window	Parameter	Value
Northern Superwindow	Shading Coefficient	0.7 (heating season) 0.3 (cooling season)
	U-value	0.1 Btu/h · ft^2 °F
Southern Superwindow	Shading Coefficient	0.15 (all seasons)
	U-value	0.2 Btu/h · ft^2 °F

Target Market

- **Market Description:** [1] New and existing residential units in all climate zones.
- **Size of Market:** [1] About 55 million manufactured units sold each year for residential and light commercial.
- **Market Introduction:** The program began before 1977; advanced window collaborative and advanced spectrally selective glazing are targeted for market introduction in FY 2003.
- **Market Penetration Goal:** See table below.

Rate of Penetration (% of annual sales)					
Building Type	**Vintage**	**Region**	**2005**	**2020**	**2030**
Residential	New	All	3	65	85
Residential	Existing	All?	1.5	33	43.2

Non-Energy Benefits:

Environmental benefits, particularly from reduced utility peak loads, comfort, aesthetics, etc.

Program/Technology Consumer Costs:

- **Incremental Cost of BTS Technology:** +$6/sq ft in 2005, +$4/sq ft in 2020, and $3/sq ft in 2030 for advanced windows over conventional double-glazed, low-emissivity windows.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Building Envelope: Windows Program* (internal BTS document).

Building Envelope R&D: Thermal Insulation and Building Materials

Equipment, Materials, and Tools Decision Unit

Program Objective: [1]

This program improves envelope performance through advanced technology and increased understanding of the basic processes governing envelope performance. Building envelopes, which influence electric lighting requirements, are the primary factor governing the heating, cooling, and ventilation requirements of buildings. Because building envelopes impact 53% of building energy use, substantial energy can be saved by improving the materials, components, and systems that make up building envelopes.

This program performs research on energy-efficient, sustainable, low-cost, and super-smart thermal insulation and building envelope materials and structures. The program develops laboratory, analytical, and field experiments and methodologies to characterize tools and testing for new or improved materials and systems. The program also provides accurate evaluation procedures.

Long-Term Goal: [1]

The program's long term goal is to develop new building materials and systems that can contribute to DOE's energy-efficiency goal of reducing annual building energy consumption by 2 quad by 2010 and 5 quad by 2020; that are cost-competitive for their application; and that are as environmentally benign and sustainable as possible. Another long-term goal of the program involves developing a fundamental understanding of heat, air, and moisture transfer through building envelopes and insulation materials and applying the results to develop construction technologies to increase building energy efficiency.

Market Segment:

Performance Objective:

- **Displaced Technology:** Conventional wall insulation and framing.
- **Performance Target:** Reduce unwanted heat gains and losses and perimeter lighting. Estimated savings per building are determined by simulating food sales, mercantile and service, warehouse, and other commercial building types and single-family residential buildings in all climate zones. National impacts will be determined in NEMS as shown in the following table.

Building Envelope R&D: Thermal Insulation and Building Materials

Program Type:
Envelope

Target Market:
All sectors in all climate zones

End Uses:
Roofs and insulation

Unit of Measurement:
% load reduction per unit (residential) and % load reduction per square foot (commercial)

Modeling Tool:
NEMS Envelope

Program Manager:
Arun Vohra

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FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.0	0.1	1.0	18.1

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.000	.001	.016	.276

Consumer Cost Savings (million $)

2002	2005	2010	2020
0	1	7	109

Parameter	Value	Units
r-value	36	Btu/h · ft^2 °F

Target Market

- **Market Description:** [1] New residential and commercial buildings. Certain elements of the program focus on retrofit strategies as well. The program activities are independent of region and household income.
- **Size of Market:** [1] All new and retrofit residential and commercial construction and all building categories.

Methodology

For FY 2001, this program was represented by advanced insulations and R30 insulation/30-year life roofs technologies. For FY 2002, this program was recharacterized using the quick fill walls and 30/30 roofs technologies, which are summarized below.

Quick Fill Walls

Description: This technology involves applying environmental wall-insulating techniques.

Performance Objective:

- **Displaced Technology:** Conventional wall insulation and framing.
- **Performance Target:** Reduce unwanted heat gains and losses and perimeter lighting. Estimated savings per building are determined by simulating food sales, mercantile and service, warehouse, and other commercial building types and single-family residential buildings in all climate zones.
- **Performance Parameters:** See the table below.

Parameter	Value
r-value	36 Btu/h · ft^2 °F

Market Penetration:

- **Target Market:** Selected commercial and residential buildings in all climate zones.
- **Market Introduction:** 2004.
- **Market Penetration Goal:** See table below.

Rate of Penetration (% of annual sales)				
Building Type	Vintage	Region	2010 (%)	2030 (%)
Food Sales, Mercantile and Service, Warehouse, and Other	New	All	1.5	7.6
Residential	New	All	2.3	11.5

R30 Insulation/30-Year Life Roofs

Description: This technology involves applying advanced roofing techniques.

Performance Objective:

- **Displaced Technology:** Conventional commercial low-slope roofs.
- **Performance Target:** Reduced unwanted heat gains and losses and perimeter lighting. Estimated savings per building will be determined by simulating all commercial building types in all climate zones. National impacts will be determined in NEMS.
- **Performance Parameters:** See the table below.

Parameter	Value
r-value	36 Btu/h · ft^2 °F

Market Penetration:

- **Target Market:** All sectors in all climate zones.
- **Market Introduction:** 2010.
- **Market Penetration Goal:** See the table below.

Rate of Penetration (% of annual sales)				
Building Type	Vintage	Region	2010 (%)	2030 (%)
All Commercial	New	All	0.6	50.5
All Commercial	Existing	All	0.4	30.2

Building Envelope R&D: Thermal Insulation and Building Materials

Equipment, Materials, and Tools Decision Unit

Non-Energy Benefits: (1)

Reduced construction and demolition waste; use of natural, recycled and byproduct materials; reduced CO_2 emissions from improved energy efficiency; increased housing affordability from reduced energy consumption; improved comfort and indoor air quality from more moisture tolerant designs and controls; and increased global competitiveness of U.S. industry.

Program Strategy (% of budget): (1)

- Research and Development – 95%
- Market Transformation – 0%
- Codes and Standards – 5%.

Sources:

(1) FY 2002 Budget Request – *Data Bucket Report for Building Envelope: Thermal Insulation and Buildings Materials Program* (internal BTS document).

Analysis Tools and Design Strategies

Equipment, Materials, and Tools Decision Unit

Program Objective:[1]

The Analysis Tools and Design Strategies program researches the interrelationship of energy systems and buildings energy performance, develops various building analysis tools to more accurately model energy use in new and existing buildings, and provides recommendations and strategies to cost effectively lower energy use and improve building performance. The program focuses on whole-building software tools for evaluating energy efficiency and renewable energy. The program also focuses on non-software solutions such as improved standards, guidelines, and performance measurements, all of which bring about excellence in designing new buildings.

Long-Term Goal:[1]

The program's long-term goal is to improve energy designs for all building types through a suite of widely used analytical tools and guidance documents.

Market Segment:

Performance Objective:

- **Displaced Technology:** Conventional design/building practice.
- **Performance Target:** Reduce heating and cooling loads by 30% in new construction by 2020.

Target Market

- **Market Description:** All new commercial and residential construction (particularly buildings with energy-use intensities >50% of the average energy-use intensity).
- **Size of Market:** New, single-family, multifamily, and mobile homes for the residential sector and assembly, education, food service, food sales, health care, lodging, mercantile and service, and office buildings for the commercial sector.
- **Market Introduction:** 1996.
- **Market Penetration Goal:** By 2020 penetrate 4% of new commercial and multifamily construction in combination with Commercial Buildings R&D program and 5% of new single-family and mobile home units.

Methodology

Analysis tools save energy by simulating the adoption of efficient technologies in the design stage of new con-

Analysis Tools and Design Strategies

Program Type:
Whole Building

Target Market:
Single-family and manufactured homeowners with >$50,000/yr income, all multifamily and commercial sector and industrial offices in all climate zones

End Uses:
All end uses and all fuel types

Unit of Measurement:
% load reduction per unit (residential) and % load reduction per square foot (commercial)

Modeling Tool:
NEMS

Program Manager:
Dru Crawley

♦♦♦♦♦♦♦♦♦♦♦♦♦

FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.0	0.0	0.5	6.5

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.000	.000	.008	.107

Consumer Cost Savings (million $)

2002	2005	2010	2020
0	0	4	51

struction and major renovation. Program savings will be modeled from the adoption of technologies for reducing space heating and cooling loads.

Non-Energy Benefits:[1]

Improved indoor environmental quality such as thermal comfort and ventilation adequacy and improved indoor air quality, fire safety, and overall environmental sustainability (i.e., Green Buildings).

Program Strategy (% of budget):[1]

- Research and Development – 90%
- Market Transformation – 10%
- Codes and Standards – 0%.

Sources:

(1) FY 2002 Budget Request - *Data Bucket Report for Analysis Tools and Design Strategies Program* (internal BTS document).

(2) *Building Technology, State and Community Programs Funding Profile for the FY 2002 Corporate Review Budget* (internal BTS document).

Lighting and Appliance Standards

Equipment, Materials, and Tools Decision Unit

Program Objective:[1]

The Lighting and Appliance Standards program achieves significant energy savings, consumer cost savings, and reduced air emissions through standards rulemaking. The program also prescribes test procedures that measure energy efficiency and energy use and that estimate the annual operating cost of each appliance.

Long-Term Goal:[1]

The program's long-term goal is to set efficiency standards that lead to substantial increases in the average efficiency of new building equipment.

Market Segment:

Target Market

- **Market Description:** All residential and commercial equipment covered by the appropriate legislation.[2,3]
- **Size of Market:** All residential and commercial equipment in the market.

Methodology

For FY 2002, the energy savings from equipment standards activities were primarily based on a PNNL developed spreadsheet to support an EPAct screening analysis conducted in late 1999 and early 2000. This spreadsheet was used to estimate the energy savings from various levels of standards for nearly 40 types of equipment covered by EPAct. The spreadsheet results were used to identify products that could achieve significant energy savings beyond the efficiency levels set in the recent ASHRAE 90.1-1999 publication.[4]

For FY 2002, the EPAct standards were assumed to continue with the products having the potential for additional energy savings. These products include boilers, three-phase residential-size cooling equipment, packaged terminal air conditioning, packaged terminal heat pump equipment, and large rooftop air-conditioning equipment. Energy-savings' estimates for these products based on the spreadsheet are shown in the next section.

The FY 2002 savings for this program also include an estimate for revised standards for residential gas furnaces. This program was modeled in the NEMS residential model. In the baseline version of the model used by EIA for its *Annual Energy Outlook 2000*, a wide range of

Lighting and Appliance Standards

Program Type:
Codes and standards for equipment efficiency

Target Market:
All sectors and all climate zones

End Uses:
All end uses and all fuel types

Unit of Measurement:
Efficiency of specific equipment

Modeling Tool:
NEMS
Spreadsheet

Program Manager:
Carl Adams

♦♦♦♦♦♦♦♦♦♦♦♦♦

FY 2002 Benefits
Primary Energy Savings (TBtu)

2002	2005	2010	2020
0.0	4.8	70.6	269.3

Carbon Equivalent Reductions (MMTCE)

2002	2005	2010	2020
.000	.089	1.176	4.685

Consumer Cost Savings (million $)

2002	2005	2010	2020
0	31	522	2051

the furnace efficiencies was available: 78%, 80%, 84%, 88%, and 96%. To estimate the standards program for furnaces, the lowest two efficiency levels were assumed to not meet the revised standard after 2007. In addition, savings related to standards covering distribution transformers were calculated in a spreadsheet based on a 1992 study conducted by Geller and Nadel.[5]

Estimated Savings for Commercial Products:

Based on the spreadsheet EPACT_SA.XLS (essentially identical to the spreadsheet installed on the BTS web site for public comment subsequent to the EPAct screening analysis), the following tables summarize the efficiency assumptions and energy savings results for products that will undergo further analysis by DOE/BTS. Table 1 summarizes the key assumptions and results for 13 cooling products, and Table 2 does the same for boilers and a high-capacity instantaneous water heater. Cumulative savings, shown in the last column in both tables, are based on the savings from the effective date of the standards through 2030.

Estimated Savings for Distribution Transformers:

Distribution transformers convert high-voltage electricity from distribution centers to lower-voltage electricity for use at the household level. During this conversion process, a small fraction of heat is lost. Rules are being written to reduce the amount of heat loss during this conversion process.

Savings' estimates for a distribution transformer standard are based on a study conducted by Geller and Nadel.[5] The study assumed the following:

- Savings of 80 watts per unit
- Annual sales of 1.2 million units
- 20% sales complying with the new level
- without the standard
- 8,760 annual operating hours per unit
- 13-year life of equipment.

The savings estimate of 80 watts per unit installed is multiplied by the estimated hours of operation and then by the forecasted number of units installed.

Estimated Savings for Residential Gas Furnaces:

Rules related to the efficiency of residential gas furnaces are being written with the anticipated adoption date of 2008.

Savings for residential gas furnaces are estimated using NEMS and the following assumptions:

- Proposed residential gas furnace efficiency of 82% annual fuel utilization efficiency

Table 1. Key Assumptions and Results for Cooling Products

	Efficiency (SEER and EER)			Energy Savings by Year (TBtu)			
Equipment Category	**EPAct 92**	**New Std**	**Eff. Date**	**2010**	**2020**	**2030**	**Cum.**
3-Phase Single Package, Air Source Air Conditioning, <65 kBtu/h	9.7	12	2005	4.6	21.0	26.5	396.0
3-Phase Single Package, Air Source Heat Pump, <65 kBtu/h	9.7	12	2005	1.2	3.1	3.4	60.2
3-Phase Split, Air Source Air Conditioning, <65 kBtu/h	9.7	11	2005	0.9	4.1	5.2	78.1
3-Phase Split, Air Source Heat Pump, <65 kBtu/h	9.7	12	2005	9.1	24.0	26.5	463.0
Central, Water Source Heat Pump, >17 and <65 kBtu/h	9.3	12.5	2008	1.5	7.1	11.1	146.9
Central, Air Source Air Conditioning, >=65 and <135 kBtu/h	8.9	11	2008	5.5	25.0	31.6	471.6
Central, Air Source Air Conditioning, >=135 and <240 kBtu/h	8.5	11	2008	5.4	24.6	31.0	463.1
Packaged Terminal Air Conditioning, 7-10 kBtu/h	8.6	10.8	2008	0.4	1.8	2.2	33.3
Packaged Terminal Air Conditioning, 10-13 kBtu/h	8.1	10.2	2008	0.6	2.6	3.3	49.5

Table 2. Key Assumptions and Results for Boilers and High-Capacity Instantaneous Water Heater							
	Efficiency (SEER and EER)			Energy Savings by Year (TBtu)			
Equipment Category	EPAct 92	New Std	Eff. Date	2010	2020	2030	Cum.
Pkg'd Boilers, Gas, 400 kBtu/h, Hot Water	75%	78%	2008	0.2	0.9	1.7	19.7
Pkg'd Boilers, Gas, 800 kBtu/h, Hot Water	75%	78%	2008	0.4	2.0	3.7	43.0
Pkg'd Boilers, Gas, 1500 kBtu/h, Hot Water	75%	78%	2008	0.1	0.7	1.2	14.2
Pkg'd Boilers, Gas, 3000 kBtu/h, Hot Water	75%	80%	2008	0.2	0.7	1.3	15.2
Pkg'd Boilers, Gas, 400 kBtu/h, Steam	72%	76%	2008	0.1	0.6	1.1	12.6
Pkg'd Boilers, Gas, 800 kBtu/h, Steam	72%	76%	2008	0.4	1.6	3.0	34.5
Pkg'd Boilers, Gas, 1500 kBtu/h, Steam	72%	79%	2008	0.3	1.2	2.3	26.7
Pkg'd Boilers, Gas, 3000 kBtu/h, Steam	72%	80%	2008	0.2	0.9	1.7	19.2
Instantaneous Water Heaters, 1000 kBtu/h	80%	83%	2008	1.0	4.4	5.6	83.3

- Introduction date of 2008
- Cost of $1400.

Non-Energy Benefits: (1)

Reduced CO_2 and SO_x emissions, reduced water consumption from plumbing equipment, increased life of equipment operating at cooler temperatures, and reduced first costs that transform new technologies into commodities.

Program Strategy (% of budget): (1)

- Research and Development – 0%
- Market Transformation – 0%
- Codes and Standards – 100%.

Sources:

(1) FY 2002 Budget Request - *Data Bucket Report for the Lighting and Appliance Standards Program* (internal BTS document).

(2) National Appliance Energy Conservation Act of 1987, Public Law 100-12.

(3) Energy Policy Act of 1992, Public Law 102-486.

(4) ASHRAE 90.1-1999, "Energy Standard for Buildings Except Low-Rise Residential Buildings."

(5) Geller, H. and S. Nadel. 1992. "Consensus National Efficiency Standards for Lamps, Motors, Showerheds and Faucets, and Commercial HVAC Equipment." In *American Council for an Energy Efficient Economy Proceeedings*, p. 6.71-6.82.

Appendix A
Baseline Assumptions

Appendix A
Baseline Scenario and Inputs for FY 2002 GPRA Metrics

To obtain the GPRA metrics for FY 2002, the following baseline scenario and inputs were used. This information is common to all programs analyzed within BESET.

Building Stock

Building stock estimates are used to estimate the total energy savings at the national level for each program. Residential and commercial new and existing building stock totals for all years through 2020 were provided by EIS's *Annual Energy Outlook 2000*. The stock estimates have been developed for each market segment (e.g., building type, building vintage, and region) based on the following assumptions.

- **Residential Single-Family and Multifamily Housing**
  - 60% of the existing building stock is in the north.
  - 40% of the existing building stock is in the south.
  - New stock is divided evenly across regions.

- **Residential Manufactured Housing**
  - 48% of the existing building stock is in the north.
  - 52% of the existing building stock is in the south.
  - 45% of the new building stock is in the north.
  - 55% of the new building stock is in the south.
  - New stock is divided evenly across regions.

- **Commercial Buildings**
  - 59% of the existing building stock is in the north.
  - 41% of the existing building stock is in the south.
  - 55% of the new building stock is in the north.
  - 45% of the new building stock is in the south.

By using the assumptions listed above, the building stock numbers are segmented by building vintage and region. The base year is 2002, and all construction beginning with 2002 is considered "new."

The building stock was disaggregated into "north" and "south" regions by using the EIA climate zones published in the Residential Energy Consumption Survey and the Commercial Buildings Energy Consumption Survey. Climate zones 1 through 3 (i.e., zones with >4,000 heating-degree days) were designated as the "north" region, and zones 4 and 5 (i.e., zones with <4,000 heating-degree days) were defined as the "south" regions (see Figure 1). Using this method, approximate percentages of north and south existing units and new construction were estimated.

Existing Equipment Market Shares

Equipment market shares were broken out by market segment and are estimated from Residential Energy Consumption Survey, the Commercial Buildings Energy Consumption Survey, and original PNNL efforts by Dave Belzer.

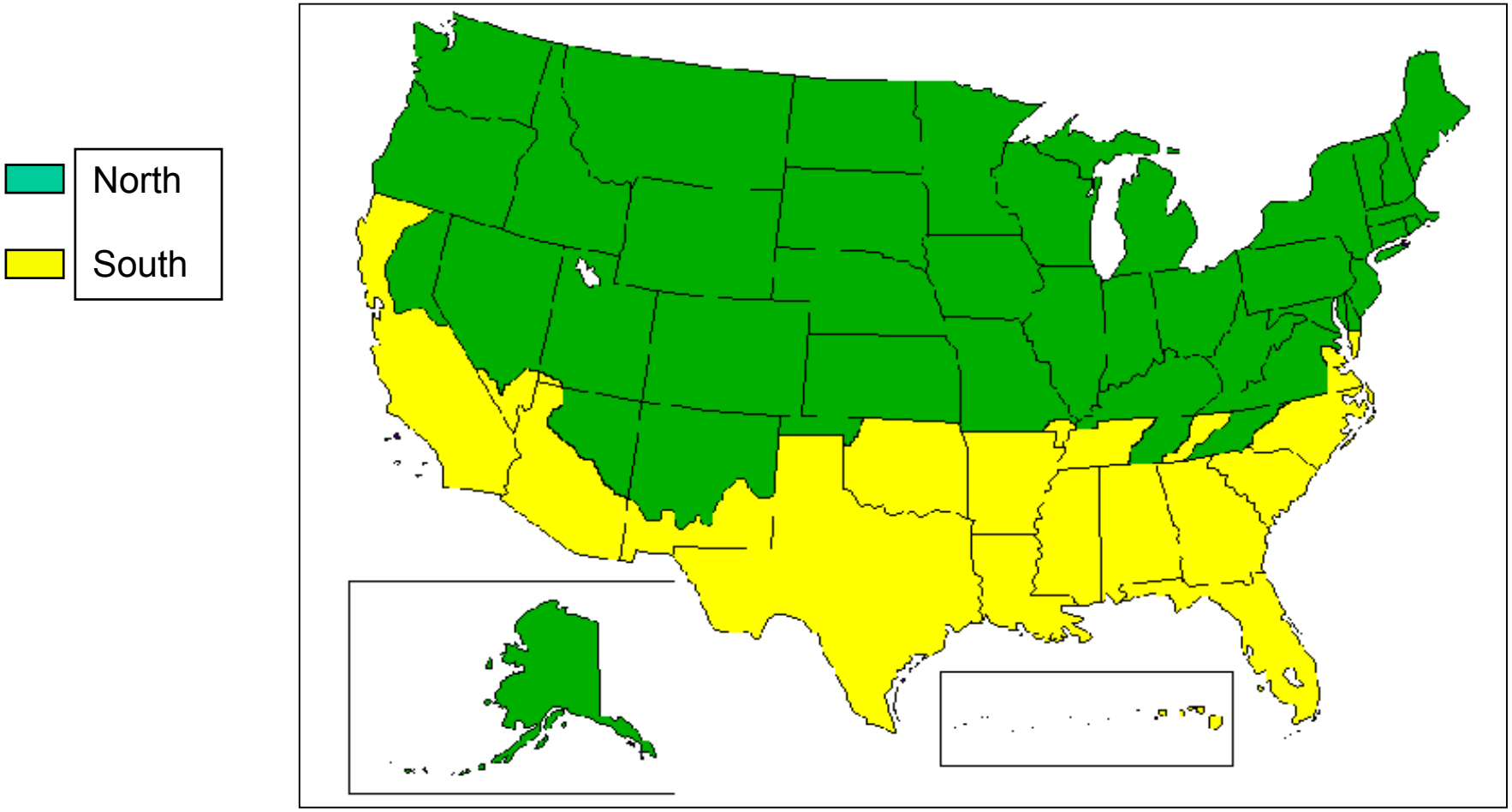


Figure 4. Regions for BTS GPRA Metrics

Existing Equipment Efficiencies

The efficiency of equipment stock was developed from EIA's 1995 *Annual Energy Outlook* and input from Program Managers. Where applicable, the assumed stock efficiency increased to meet equipment standards.

Equipment Life

Equipment replacement factors are used in calculating the number of units representing the potential target market for programs targeting specific pieces of equipment. BTS technologies are assumed to compete only with "new" units. For new buildings, all units are considered new; therefore, the replacement factor for equipment in new buildings is 1.0.

For existing buildings, only units scheduled to be replaced are considered to be eligible for the BTS technology. In other words, the BTS technology is assumed not to replace a piece of equipment unless it was going to be replaced anyway. The replacement factor for existing buildings for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1998 to 2000; the factor for 2005 represents the turnover percentage from 2001 to 2005, etc.). The replacement factors are based on the specific equipment's life expectancy. Baseline factors are taken from *Appliance Magazine*, NEMS, and the *BTS Core Data Book*.

Sources

Annual Energy Outlook, 1995, Energy Information Administration, Washington, D.C.

Annual Energy Outlook, 2000, Energy Information Administration, Washington, D.C.

BTS Core Databook, internal BTS document, U.S. Department of Energy.

Appliance Magazine. 1998. "Life Expectancy/Replacement Picture," 55(9):71.

Appendix B
GPRA Data Cell

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy

GPRA Data Call

Fiscal Year 2002

July 13, 2000

Form available on GPRAWeb at http://analysis.nrel.gov/gpraweb

APPENDIX B

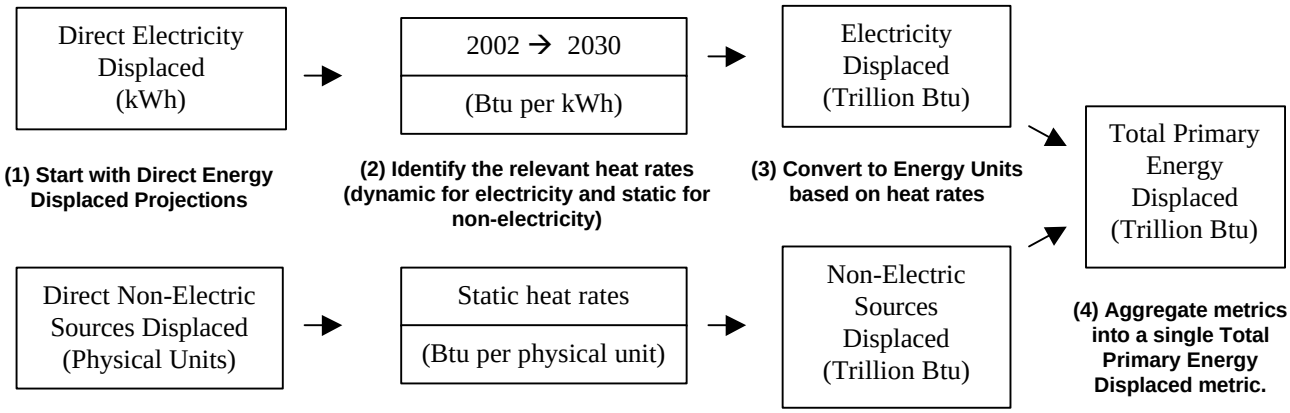
Calculation Methodologies and AEO2000 Baseline Assumptions

There are a variety of methods and assumptions that may be used to calculate the benefits of EERE programs. However, certain methodologies and assumptions may be applied to all of EERE's programs. This appendix provides methodologies and baseline assumptions for calculating energy, financial and environmental metrics requested in the GPRA2002 Data Call. Baseline assumptions are drawn from the Energy Information Administration's Annual Energy Outlook 2000 (AEO2000) and its supporting documentation.

Calculation Methodologies

Converting from Direct to Primary Energy Displaced

The process for converting projections of direct energy displaced into a single total primary energy displaced metric involves four steps. These steps are displayed in the diagram below.



(1) The first step in the conversion process is to identify the electric and non-electric displaced energy projections. The direct electricity displaced projections will be expressed in kilowatt-hours; the direct non-electric projections will be expressed in barrels of oil, cubic feet of natural gas, and short tons of coal.

(2) The next step involves the conversion from direct units into heat content units using the heat rate of each direct fuel source.

Electricity Heat Rates

Electricity heat rates for GPRA2002 were derived by comparing the AEO2000 reference case against a side case in which electricity demand was reduced. The first step was to determine the marginal fuel mix based on the differences in kWh of electricity generated. The results, shown in the table below, indicate that EERE technologies are projected to displace electricity generated from fossil fuels.

Projected Marginal Fuel Generation Mix
(based on marginal kWh generated)

Fuel Mix	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Coal	33.9%	30.2%	27.8%	21.5%	25.1%	16.7%	17.1%	26.3%	32.9%	32.9%
Natural Gas	48.1%	52.0%	55.1%	56.4%	56.9%	75.7%	71.8%	65.5%	60.1%	60.1%
Oil	18.0%	17.8%	17.0%	22.0%	18.0%	7.6%	11.1%	8.2%	7.0%	7.0%

The second step was to calculate the marginal electricity heat rates for each fuel source based on a comparison of the two cases. The results are shown in the table below.

Projected Marginal Electricity Heat Rates by Fuel Source

Projected Electricity Heat Rates	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Coal (Btu per kWh)	11489	11108	11271	11530	11287	10212	10388	8801	8801	8801
Natural Gas (Btu per kWh)	10989	10967	10182	9557	9432	7724	7413	7031	7031	7031
Oil (Btu per kWh)	10363	10510	10702	10732	10408	10501	10590	10298	10298	10298

To derive the dynamic GPRA2002 electricity heat rates, the percentage of the marginal mix associated with each fuel source was multiplied by the expected electricity heat rate for the same source. This yielded the intermediate apportioned heat content associated with each generation source. Then, for each forecast year, the apportioned heat contents were summed to arrive at a final GPRA2002 heat rate. For example, in the year 2020, electricity generated from coal is expected to account for 26.3 percent of the marginal mix, electricity generated from natural gas 65.5 percent, and oil 8.2 percent. The expected electricity heat rates in 2020 for coal, natural gas and oil are 8,801 and 7,031 and 10,298 Btu/kWh, respectively. Therefore, the GPRA2002 heat rate for 2020 is (26.3%)(8,801) + (65.5%)(7,031) + (8.2%)(10,298) = 7,765 Btu/kWh.

GPRA2002 Electricity Heat Rates

GPRA2002 Heat Rate	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (Btu per kWh)	11045	10928	10574	10241	10074	8350	8276	7765	7839	7839

Non-Electric Heat Rates

The heat rates used for conversion of non-electric sources are much more straightforward. The table below contains the appropriate conversion factors for these sources that are based on heat rate estimates provided in AEO2000 Table H1. Simply find the matching direct energy displaced source with the appropriate heat rate from the table below.

GPRA2002 Non-Electricity Heat Rates

Coal			
	Coal Production	million Btu per short ton	21.296
	Coal Consumption	million Btu per short ton	20.835
	Coke Plants	million Btu per short ton	26.800
	Industrial	million Btu per short ton	22.172
	Residential and Commercial	million Btu per short ton	22.494
	Electric Utilities	million Btu per short ton	20.548
Oil			
	Crude Oil Production	million Btu per barrel	5.800
	Oil Products Consumption	million Btu per barrel	5.358
	Motor Gasoline	million Btu per barrel	5.213
	Jet Fuel (Kerosene)	million Btu per barrel	5.670
	Distillate Fuel Oil	million Btu per barrel	5.825
	Residual Fuel Oil	million Btu per barrel	6.287
	Liquefied Petroleum Gas	million Btu per barrel	3.625
	Kerosene	million Btu per barrel	5.670
	Petrochemical Feedstocks	million Btu per barrel	5.630
	Unfinished Oils	million Btu per barrel	5.800
Natural Gas			
	Natural Gas Production	Btu per cubic foot	1,028
	Natural Gas Consumption	Btu per cubic foot	1,028
	Non-electric Utilities	Btu per cubic foot	1,029
	Electric Utilities	Btu per cubic foot	1,022

Source: AEO2000, Table H1.

(3) The third step involves multiplying the above heat rates by the direct energy displaced projections.

(4) The final step is to sum the energy displaced estimates (not expressed in heat content units) for each forecast year.

Converting from Direct to Primary Energy – An Example

To better understand the mechanics of the energy conversion process, consider the following example. The direct energy displaced projections for a hypothetical Planning Unit EE are displayed in the table below. Assume Planning Unit EE is a demand-side technological development program which displaces electricity and natural gas in the commercial buildings sector.

Step 1 consists of simply identifying the direct energy displaced estimates for each forecast year.

Step (1)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Direct Electricity Displaced (billion kWhs)	0.00	0.50	1.20	2.10	3.20	11.00	25.00	41.00	61.00	90.00
Direct Natural Gas Displaced (billion cubic feet)	1.00	2.00	3.50	5.50	8.20	31.00	66.00	102.00	150.00	200.00

In step 2, the relevant heat rates are identified. A static conversion factor is used for the non-electric projections while a dynamic heat rate is used for electricity.

Step (2)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (Btu per kWh)	11045	10928	10574	10241	10074	8350	8276	7765	7839	7839
Natural Gas Consumption (Btu per cubic foot)	1028	1028	1028	1028	1028	1028	1028	1028	1028	1028

In step 3, all direct energy displaced estimates are converted from physical units to heat content units by multiplying by the appropriate heat rates.

Step (3)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (trillion Btu)	0.00	5.46	12.69	21.51	32.24	91.85	206.89	318.37	478.18	705.52
Natural Gas (trillion Btu)	1.03	2.06	3.60	5.65	8.43	31.87	67.85	104.86	154.20	205.60

After all of the metrics have been converted to heat content units, the last step involves summing the metrics in each forecast year.

Step (4)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Total Primary Energy Displaced (trillion Btu)	1.03	7.52	16.29	27.16	40.66	123.72	274.74	423.23	632.38	911.12

Calculating Energy Cost Savings

The methodology for calculating energy cost savings differs slightly for electricity and non-electricity energy sources. For non-electricity energy sources, sector energy prices are applied to the projections of primary energy displaced by energy source to obtain energy cost savings by energy source. For electricity, the amount of direct electricity displaced in kWh is converted to site electricity in trillion btu and then multiplied by the sector electricity price. Electricity and non-electricity cost savings estimates are then summed to arrive at total energy cost savings. The GPRA2002 Data Call uses energy prices in Table 20 of the Assumptions to the AEO2000 (found later in Appendix B).

Calculating Energy Cost Savings – An Example

To better understand how to calculate energy cost savings, consider the following example. The process starts with the estimates of direct energy displaced.

Step (1)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Direct Electricity Displaced (billion kWhs)	0.00	0.50	1.20	2.10	3.20	11.00	25.00	41.00	61.00	90.00
Direct Natural Gas Displaced (billion cubic feet)	1.00	2.00	3.50	5.50	8.20	31.00	66.00	102.00	150.00	200.00

Heat rates are applied to the estimates. Note that an electricity *consumption* heat rate is used.

Step (2)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity Consumption (Btu per kWh)	3412	3412	3412	3412	3412	3412	3412	3412	3412	3412
Natural Gas Consumption (Btu per cubic foot)	1028	1028	1028	1028	1028	1028	1028	1028	1028	1028

This results in the heat content for each energy source.

Step (3)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Site Electricity (trillion Btu)	0.00	1.71	4.09	7.17	10.92	37.53	85.30	139.89	208.13	307.08
Natural Gas (trillion Btu)	1.03	2.06	3.60	5.65	8.43	31.87	67.85	104.86	154.20	205.60

Appropriate energy prices are applied (commercial buildings sector prices are used here).

Step (4)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity ($ per million Btu)	20.13	19.91	19.69	19.31	19.26	18.65	18.37	18.17	17.44	16.73
Natural Gas ($ per million Btu)	5.42	5.43	5.45	5.48	5.52	5.53	5.48	5.50	5.55	5.60

Resulting in energy cost savings projections for each fuel.

Step (5)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity ($ billions)	0.00	0.03	0.08	0.14	0.21	0.70	1.57	2.54	3.63	5.14
Natural Gas ($ billions)	0.01	0.01	0.02	0.03	0.05	0.18	0.37	0.58	0.86	1.15

Individual fuel savings estimates are summed to arrive at a final metric of energy cost savings (components may not sum to totals due to rounding).

Step (6)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Total Energy Cost Savings ($ billions)	0.01	0.05	0.10	0.17	0.26	0.88	1.94	3.12	4.48	6.29

Calculating Carbon Equivalent Emissions Displaced

The methodology for calculating the level of carbon equivalent emissions displaced continues from the conversion of direct to primary energy displaced. Emission factors for carbon are applied to the projections of primary energy displaced by energy source to obtain carbon equivalent emissions displaced by energy source. These estimates are then summed to arrive at a final metric of carbon equivalent emissions displaced.

The GPRA2002 Data Call uses carbon emission factors found in Table 2 of the Assumptions to the AEO2000. These emission factors are based on the carbon content of the fuel and the fraction of the fuel consumed in combustion. The emission factors are based on 1998 data.

Adjusted Carbon Emission Factors (1998)
(Million Metric Tons of Carbon per Trillion Btu)

Fuel		Emission Factor
Petroleum		
	Motor Gasoline	0.01914
	LPG	
	Used as Fuel	0.01711
	Used as Feedstock	0.00337
	Jet Fuel	0.01914
	Distillate Fuel	0.01975
	Residual Fuel	0.02128
	Asphalt and Road Oil	0.00000
	Lubricants	0.01214
	Petrochemical Feedstocks	0.00387
	Kerosene	0.01952
	Petroleum Coke	0.01393
	Petroleum Still Gas	0.01742
	Other Industrial	0.02011
Coal		
	Residential and Commercial	0.02566
	Metallurgical	0.02529
	Industrial Other	0.02539
	Electric Utility	0.024486
Natural Gas		
	Used as Fuel	0.01440
	Used as Feedstocks	0.01120

Like the electricity heat rate, the carbon emission factor for electricity changes over the forecast period with the changing projections of the marginal fuel mix. The petroleum mix for the utility sector is 95% residual fuel and 5% distillate fuel.

Electricity Carbon Emission Factor
(million metric tons of carbon per trillion Btu)

Carbon Coefficient	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (MMTCE per trillion Btu)	0.01910	0.01866	0.01856	0.01842	0.01850	0.01711	0.01754	0.01815	0.01875	0.01875

Calculating Carbon Equivalent Emissions Displaced – An Example

To better understand how to calculate displacement of carbon equivalent emissions, consider the following example, which continues from Step 3 of the direct-to-primary energy example.

Step (3)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (trillion Btu)	0.00	5.46	12.69	21.51	32.24	91.85	206.89	318.37	478.18	705.52
Natural Gas (trillion Btu)	1.03	2.06	3.60	5.65	8.43	31.87	67.85	104.86	154.20	205.60

Instead of summing these metrics to arrive at a final total primary energy displaced metric, the appropriate carbon emissions coefficients are applied.

Step (4)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (MMTCE per trillion Btu)	0.01910	0.01866	0.01856	0.01842	0.01850	0.01711	0.01754	0.01815	0.01875	0.01875
Natural Gas (MMTCE per trillion Btu)	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440

The resultant emissions displaced projections are listed in the table below.

Step (5)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (MMTCE)	0.00	0.10	0.24	0.40	0.60	1.57	3.63	5.78	8.97	13.23
Natural Gas (MMTCE)	0.01	0.03	0.05	0.08	0.12	0.46	0.98	1.51	2.22	2.96

The final step is to sum these individual estimates to arrive at a final metric of carbon equivalent emissions displaced as illustrated below (components may not sum to totals due to rounding).

Step (6)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Carbon Equivalent Emissions Displaced (MMTons)	0.01	0.13	0.29	0.48	0.72	2.03	4.61	7.29	11.19	16.19

Calculating Criteria Pollutants Displaced

Calculating the amount of criteria pollutants displaced is similar to calculating the displacement of carbon equivalent emissions. Emission factors are applied to primary energy displaced by energy source to obtain criteria pollutant displacement levels by energy source. These estimates as then summed to obtain total criteria pollutant displaced levels.

The Environmental Protection Agency catalogues emission factors for numerous technologies. For the GPRA Data Call more generic emission factors have been calculated from aggregate emission and energy consumption data provided by EPA for 1997. These are provided in the tables below. Emission factors for specific technologies may be obtained from EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) available on the world wide web at http://www.epa.gov/ttn/chief/ap42etc.html

Emission Factors of Criteria Pollutants
(MMTons of emissions per trillion Btu)

Fuel	NOx	SO2	VOCs	CO	PM10
Coal	0.000254	0.000568	0.000001	0.000011	0.000012
Natural Gas	0.000106	0.000000	0.000003	0.000029	0.000000
Oil	0.000140	0.000527	0.000004	0.000013	0.000007

Like the electricity carbon emission factor, the electricity criteria pollutant emission factors are dynamic, changing over time with the changing fuel mix.

Electricity Emission Factors of Criteria Pollutants
(MMTons of emissions per trillion Btu)

Criteria Coefficients	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
NOx (MMTons per trillion Btu)	0.000164	0.000157	0.000156	0.000150	0.000154	0.000140	0.000143	0.000154	0.000164	0.000164
SO2 (MMTons per trillion Btu)	0.000289	0.000265	0.000260	0.000260	0.000258	0.000166	0.000197	0.000227	0.000258	0.000258
VOCs (MMTons per trillion Btu)	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000002	0.000002
CO (MMTons per trillion Btu)	0.000020	0.000021	0.000021	0.000021	0.000021	0.000024	0.000023	0.000022	0.000021	0.000021
PM10 (MMTons per trillion Btu)	0.000005	0.000005	0.000005	0.000005	0.000005	0.000003	0.000004	0.000004	0.000005	0.000005

Calculating Criteria Pollutant Emissions Displaced – An Example

To better understand the calculations behind criteria pollutants displaced, consider the following example for calculating emissions of NOx displaced. Similar steps would be taken for calculating SO2, VOCs, CO and PM10. Steps 1-3 of the energy conversion process for Planning Unit EE yielded the following energy displacement estimates by fuel source.

Step (3)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (trillion Btu)	0.00	5.46	12.69	21.51	32.24	91.85	206.89	318.37	478.18	705.52
Natural Gas (trillion Btu)	1.03	2.06	3.60	5.65	8.43	31.87	67.85	104.86	154.20	205.60

Instead of summing these metrics to arrive at a total primary energy displaced metric, the appropriate emission factors are applied.

Step (4)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (MMTon of NOx per trillion Btu)	0.000164	0.000157	0.000156	0.000150	0.000154	0.000140	0.000143	0.000154	0.000164	0.000164
Natural Gas (MMTons of NOx per trillion Btu)	0.000106	0.000106	0.000106	0.000106	0.000106	0.000106	0.000106	0.000106	0.000106	0.000106

The resultant emissions displaced for NOx are listed in the table below. Similar calculations would be performed for SO2, VOCs, CO and PM10.

Step (5)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity (MMTons NOx)	0.000	0.001	0.002	0.003	0.005	0.013	0.030	0.049	0.078	0.116
Natural Gas (MMTons NOx)	0.000	0.000	0.000	0.001	0.001	0.003	0.007	0.011	0.016	0.022

The final step is to sum these individual estimates to arrive at a final metric of NOx emissions displaced as illustrated below.

Step (6)	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
NOx Displaced (MMTons)	0.000	0.001	0.002	0.004	0.006	0.016	0.037	0.060	0.095	0.138

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CROSSCUTTING

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* Tables in the AEO2000 contain projections to 2020. These projections have been extended to 2030 using the average growth rate from 1998-2020.

** Table 17 is from AEO2000 Model Output

Please contact John Mortensen at NREL (john_mortensen@nrel.gov) if you would like copies of the above tables in spreadsheet format. All AEO99 supplemental tables may be found on the EIA website at **http://www.eia.doe.gov/oiaf/aeo/supplement/index.html**

Table 20. Energy Prices by Sector and Source
(1998 Dollars per Million Btu, Unless Otherwise Noted)
United States Average

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Residential	13.07	13.07	13.08	13.03	13.08	13.09	13.08	13.10	13.05	13.01
Primary Energy 1/	7.13	7.12	7.13	7.15	7.16	7.11	6.99	6.92	6.96	7.00
Petroleum Products 2/	9.35	9.41	9.46	9.48	9.54	9.73	9.88	10.04	10.73	11.47
Distillate Fuel	7.45	7.51	7.53	7.55	7.59	7.74	7.82	7.88	8.35	8.84
Liquefied Petroleum Gas	13.02	13.02	13.10	13.06	13.09	13.21	13.37	13.62	14.48	15.39
Natural Gas	6.60	6.59	6.60	6.62	6.64	6.57	6.43	6.36	6.31	6.26
Electricity	22.35	22.25	22.17	21.90	21.92	21.67	21.50	21.33	20.85	20.38
Commercial	12.60	12.53	12.46	12.32	12.34	12.14	12.04	12.00	11.75	11.52
Primary Energy 1/	5.42	5.43	5.46	5.49	5.52	5.54	5.51	5.53	5.64	5.76
Petroleum Products 2/	6.04	6.08	6.11	6.12	6.15	6.27	6.36	6.49	7.04	7.63
Distillate Fuel	5.29	5.35	5.36	5.38	5.42	5.56	5.63	5.73	6.24	6.81
Residual Fuel	3.66	3.67	3.69	3.70	3.71	3.74	3.79	3.87	4.28	4.73
Natural Gas 3/	5.42	5.43	5.45	5.48	5.52	5.53	5.48	5.50	5.55	5.60
Electricity	20.13	19.91	19.69	19.31	19.26	18.65	18.37	18.17	17.44	16.73
Industrial 4/	5.39	5.38	5.39	5.38	5.41	5.48	5.55	5.65	5.84	6.04
Primary Energy	4.11	4.13	4.16	4.18	4.21	4.32	4.42	4.55	4.85	5.18
Petroleum Products 2/	5.78	5.79	5.81	5.79	5.80	5.88	5.97	6.11	6.52	6.96
Distillate Fuel	5.39	5.45	5.47	5.49	5.53	5.66	5.71	5.89	6.42	7.00
Liquefied Petroleum Gas	7.82	7.79	7.85	7.79	7.80	7.87	8.00	8.25	8.54	8.83
Residual Fuel	3.14	3.15	3.16	3.17	3.19	3.23	3.30	3.38	3.62	3.88
Natural Gas 5/	2.91	2.95	3.00	3.08	3.15	3.28	3.38	3.50	3.73	3.97
Metallurgical Coal	1.71	1.69	1.68	1.66	1.65	1.60	1.56	1.50	1.45	1.41
Steam Coal	1.36	1.35	1.34	1.32	1.31	1.26	1.21	1.16	1.11	1.05
Electricity	12.46	12.29	12.14	11.92	11.92	11.66	11.43	11.27	10.89	10.53
Transportation	8.97	9.00	9.03	9.08	9.06	9.13	9.11	9.04	9.42	9.82
Primary Energy	8.95	8.98	9.01	9.06	9.04	9.11	9.09	9.02	9.40	9.80
Petroleum Products 2/	8.95	8.98	9.02	9.06	9.04	9.11	9.08	9.01	9.39	9.79
Distillate Fuel 6/	8.86	8.88	8.88	8.90	8.92	9.01	9.02	8.97	9.34	9.72
Jet Fuel 7/	5.23	5.27	5.32	5.39	5.46	5.74	5.89	5.91	6.44	7.02
Motor Gasoline 8/	10.16	10.21	10.26	10.33	10.29	10.35	10.35	10.30	10.75	11.22
Residual Fuel	3.08	3.09	3.11	3.13	3.15	3.21	3.30	3.39	3.73	4.10
Liquid Petroleum Gas 9/	13.52	13.52	13.56	13.52	13.51	13.48	13.47	13.50	14.14	14.82
Natural Gas 10/	6.23	6.28	6.39	6.54	6.71	7.22	7.45	7.49	7.92	8.39
Ethanol (E85) 11/	16.96	17.42	17.47	17.54	17.49	17.66	17.74	17.79	18.68	19.62
Methanol (M85) 12/	12.20	13.65	13.67	14.01	14.01	14.32	14.38	14.42	16.05	17.87
Electricity	15.36	15.15	14.92	14.62	14.52	14.15	13.68	13.38	12.77	12.18
Average End-Use Energy	8.77	8.77	8.77	8.76	8.77	8.81	8.81	8.81	8.98	9.16
Primary Energy	8.42	8.42	8.43	8.43	8.43	8.49	8.49	8.49	8.71	8.93
Electricity	18.49	18.31	18.16	17.85	17.85	17.50	17.24	17.06	16.54	16.03
Electric Generators 13/										
Fossil Fuel Average	1.45	1.43	1.43	1.44	1.47	1.55	1.64	1.67	1.71	1.76
Petroleum Products	3.17	3.21	3.24	3.23	3.21	3.28	3.40	3.54	3.93	4.37
Distillate Fuel	4.89	4.93	4.96	4.98	5.03	5.12	5.10	5.23	5.85	6.54
Residual Fuel	3.06	3.09	3.12	3.11	3.10	3.13	3.19	3.30	3.63	3.99
Natural Gas	2.62	2.65	2.72	2.79	2.88	3.08	3.21	3.33	3.61	3.91
Steam Coal	1.16	1.14	1.12	1.11	1.10	1.07	1.03	0.98	0.93	0.88
Average Price to All Users 14/										
Petroleum Products 2/	8.11	8.14	8.19	8.22	8.21	8.32	8.35	8.35	8.80	9.27
Distillate Fuel	7.99	8.03	8.04	8.06	8.09	8.19	8.22	8.22	8.64	9.08
Jet Fuel	5.23	5.27	5.32	5.39	5.46	5.74	5.89	5.91	6.44	7.02
Liquefied Petroleum Gas	8.86	8.84	8.91	8.86	8.88	8.93	9.02	9.22	9.59	9.98
Motor Gasoline 8/	10.16	10.21	10.26	10.33	10.29	10.35	10.35	10.30	10.75	11.22
Residual Fuel	3.11	3.13	3.16	3.16	3.17	3.23	3.31	3.40	3.73	4.10
Natural Gas	4.17	4.17	4.21	4.23	4.27	4.29	4.26	4.31	4.40	4.50
Coal	1.18	1.15	1.14	1.13	1.12	1.09	1.04	0.99	0.94	0.89
Ethanol (E85) 11/	16.96	17.42	17.47	17.54	17.49	17.66	17.74	17.79	18.68	19.62
Methanol (M85) 12/	12.20	13.65	13.67	14.01	14.01	14.32	14.38	14.42	16.05	17.87
Electricity	18.49	18.31	18.16	17.85	17.85	17.50	17.24	17.06	16.54	16.03

Table 20. Energy Prices by Sector and Source
(1998 Dollars per Million Btu, Unless Otherwise Noted)
United States Average

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Non-Renewable Energy Expentures										
by Sector (billion 1998 dollars)										
Residential	139.62	140.76	142.55	142.85	144.61	150.04	155.58	161.86	169.81	178.15
Commercial	100.15	100.53	101.02	101.07	102.27	105.14	108.63	109.62	112.75	115.96
Industrial	112.64	114.83	116.87	118.54	120.66	126.14	134.52	142.83	154.45	167.02
Transportation	243.85	249.41	255.95	262.48	267.19	288.11	309.47	326.66	370.30	419.78
Total Non-Renewable Expend	596.26	605.53	616.38	624.94	634.74	669.44	708.19	740.97	804.02	872.45
Transportation Renewable Expenditures	0.30	0.38	0.47	0.57	0.66	1.01	1.31	1.41	3.16	7.06
Total Expenditures	596.56	605.91	616.86	625.50	635.40	670.44	709.50	742.38	805.89	874.83

1/ Weighted average price includes fuels below as well as coal.
2/ This quantity is the weighted average for all petroleum products, not just those listed below.
3/ Excludes independent power producers.
4/ Includes cogenerators.
5/ Excludes uses for lease and plant fuel.
6/ Low sulfur diesel fuel. Price includes Federal and State taxes while excluding county and local taxes.
7/ Kerosene-type jet fuel. Price includes Federal and State taxes while excluding county and local taxes.
8/ Sales weighted-average price for all grades. Includes Federal and State taxes and assumes county and local taxes of 2 cents per gallon.
9/ Includes Federal and State taxes while excluding county and local taxes.
10/ Compressed natural gas used as a vehicle fuel. Price includes estimated motor vehicle fuel taxes.
11/ E85 is 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable).
12/ M85 is 85 percent methanol and 15 percent motor gasoline.
13/ Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
14/ Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding.
The historical data used were the most current available as of July 31, 1999. At that time, most regional data for 1998 were not available. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also, please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 prices for gasoline, distillate, and jet fuel are based on prices in various issues of Energy Information Administration (EIA), Petroleum Marketing Monthly, DOE/EIA-0380 (98/03-99/04) (Washington, DC, 1998-99). 1998 prices for all other petroleum products are derived from the EIA,State Energy Price and Expenditure Report 1995, DOE/EIA-0376(95) (Washington, DC, August 1998). 1997 and 1998 industrial gas delivered prices are based on EIA, Manufacturing Energy Consumption Survey 1994. 1998 residential and commercial natural gas delivered prices: EIA Natural Gas Monthly, DOE/EIA-0130(99/06) (Washington, DC, June 1999). 1998 coal prices based on EIA, Quarterly Coal Report , DOE/EIA-0121(99/1Q) (Washington, DC, August 1999), and EIA, AEO 2000 National Energy Modeling System run AEO2K.D100199A. 1998 electricity prices for commercial, industrial, and transportation: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 21. Residential Sector Supplement Table

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Equipment Stock (million units)										
Main Space Heaters										
Electric Heat Pumps	10.47	10.67	10.88	11.02	11.15	11.65	12.32	12.98	13.91	14.90
Electric Other	20.50	20.63	20.77	20.88	20.99	21.50	22.17	22.81	23.49	24.20
Natural Gas Heat Pumps	0.10	0.12	0.14	0.17	0.19	0.28	0.42	0.64	1.39	3.00
Natural Gas Other	57.63	58.45	59.27	60.20	61.12	64.63	68.60	72.26	77.09	82.25
Distillate	9.25	9.21	9.16	9.11	9.06	8.84	8.57	8.27	8.03	7.79
Liquid Petroleum Gas	5.02	5.07	5.12	5.15	5.17	5.23	5.22	5.17	5.27	5.38
Kerosene	0.92	0.91	0.90	0.89	0.88	0.85	0.81	0.77	0.73	0.70
Wood Stoves	2.16	2.16	2.16	2.15	2.14	2.12	2.11	2.12	2.10	2.09
Geothermal Heat Pumps	0.48	0.51	0.54	0.60	0.67	0.92	1.22	1.50	2.05	2.81
Total	106.54	107.73	108.94	110.17	111.38	116.03	121.45	126.51	132.96	139.74
Space Cooling (million units)										
Electric Heat Pumps	10.47	10.67	10.88	11.02	11.15	11.65	12.32	12.98	13.91	14.90
Natural Gas Heat Pumps	0.10	0.12	0.14	0.17	0.19	0.28	0.42	0.64	1.39	3.00
Geothermal Heat Pumps	0.48	0.51	0.54	0.60	0.67	0.92	1.22	1.50	2.05	2.81
Central Air Conditioners	44.02	44.97	45.92	46.89	47.85	51.50	55.70	59.53	65.13	71.25
Room Air Conditioners	37.15	37.18	37.22	37.26	37.31	37.52	37.80	38.06	38.29	38.52
Total	92.23	93.45	94.69	95.94	97.16	101.87	107.47	112.71	119.50	126.69
Water Heaters (million units)										
Electric	41.69	42.10	42.53	42.90	43.27	44.79	46.71	48.48	50.62	52.86
Natural Gas	56.45	57.18	57.93	58.77	59.59	62.74	66.36	69.78	74.14	78.78
Distillate	5.06	5.04	5.02	4.99	4.97	4.85	4.69	4.53	4.41	4.29
Liquid Petroleum Gas	3.68	3.73	3.79	3.82	3.86	3.95	3.98	3.99	4.16	4.33
Solar Thermal	0.35	0.35	0.35	0.35	0.34	0.34	0.33	0.32	0.32	0.31
Total	107.22	108.40	109.60	110.83	112.04	116.67	122.07	127.11	133.53	140.27
Cooking Equipment (million units) 1/										
Electric	66.08	66.81	67.54	68.27	68.99	71.82	75.04	78.27	82.20	86.32
Natural Gas	35.90	36.32	36.76	37.25	37.73	39.53	41.80	43.68	46.17	48.81
Liquid Petroeum Gas	4.52	4.55	4.58	4.60	4.62	4.62	4.56	4.50	4.55	4.61
Total	106.49	107.68	108.89	110.12	111.33	115.97	121.40	126.45	132.90	139.67
Clothes Dryers (million units)										
Electric	61.71	62.82	63.94	65.05	66.15	70.26	74.93	79.23	85.39	92.03
Natural Gas	17.43	17.83	18.24	18.65	19.06	20.64	22.53	24.32	26.81	29.55
Total	79.14	80.65	82.17	83.70	85.20	90.90	97.46	103.55	112.17	121.51
Other Appliances (million units)										
Refrigerators	121.54	122.76	124.01	125.29	126.54	131.33	136.89	142.07	148.63	155.49
Freezers	33.59	33.56	33.52	33.51	33.51	33.47	33.73	34.36	34.52	34.67
Stock Average Equipment Efficiency										
Main Space Heaters										
Electric Heat Pumps (HSPF)	7.19	7.22	7.23	7.24	7.25	7.24	7.30	7.43	7.54	7.66
Natural Gas Heat Pumps (HSPF)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Geothermal Heat Pumps (COP)	3.40	3.40	3.40	3.40	3.40	3.40	3.44	3.61	3.66	3.71
Natural Gas Furnace (AFUE)	0.77	0.78	0.78	0.79	0.80	0.82	0.83	0.84	0.86	0.89
Distillate Furnace (AFUE)	0.80	0.80	0.80	0.81	0.81	0.81	0.82	0.82	0.83	0.84
Space Cooling										
Electric Heat Pumps (SEER)	10.78	10.85	10.90	10.96	11.00	11.08	11.19	11.41	11.69	11.98
Natural Gas Heat Pumps (SEER)	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60
Geothermal Heat Pumps (EER)	13.50	13.50	13.50	14.68	15.33	17.68	19.48	17.28	18.28	19.33
Cent. Air Conditioners (SEER)	10.54	10.61	10.66	10.75	10.81	10.98	11.16	11.37	11.68	12.00
Room Air Conditioners (EER)	8.92	9.03	9.12	9.21	9.29	9.52	9.73	9.80	10.12	10.45
Water Heaters										
Electric (EF)	0.87	0.87	0.87	0.88	0.88	0.88	0.88	0.89	0.89	0.89
Natural Gas (EF)	0.55	0.55	0.55	0.55	0.56	0.56	0.57	0.57	0.58	0.58
Distillate (EF)	0.54	0.54	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53
Liquid Petroleum Gas (EF)	0.55	0.56	0.56	0.56	0.56	0.57	0.58	0.59	0.60	0.62

Table 21. Residential Sector Supplement Table

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Other Appliances (kilowatthours per year)										
Refrigerators	822.70	790.08	759.92	732.00	706.30	618.99	548.87	514.40	448.75	391.48
Freezers	586.93	565.38	545.42	528.13	514.12	476.26	451.38	441.81	400.81	363.62
Building Shell Efficiency Index										
Space Heating										
Pre-1998 Homes	0.93	0.93	0.92	0.92	0.91	0.90	0.88	0.87	0.85	0.83
New Construction	0.86	0.86	0.85	0.85	0.85	0.84	0.82	0.80	0.79	0.77
All Homes	0.92	0.92	0.91	0.91	0.91	0.89	0.87	0.86	0.84	0.82
Space Cooling										
Pre-1998 Homes	0.94	0.93	0.93	0.93	0.92	0.91	0.89	0.88	0.86	0.85
New Construction	0.86	0.86	0.86	0.86	0.86	0.85	0.82	0.80	0.78	0.77
All Homes	0.93	0.92	0.92	0.92	0.91	0.90	0.88	0.87	0.85	0.83

1/ Does not include microwave ovens or outdoor grills.

HSPF = Heating Seasonal Performance Factor: The total heating output of a heat pump in Btu during its normal annual usage period for heating divided by total electric input in watt-hours during the same period.

COP = Coefficient of Performance: Energy efficiency rating measure determined, under specific testing conditions, by dividing the energy output by the energy input.

AFUE = Annual Fuel Utilization Efficiency: Efficiency rating based on average usage, including on and off cycling, as set out in the standardized Department of Energy test procedures.

SEER = Seasonal Energy Efficiency Ratio: The total cooling of a central unitary air conditioner or a unitary heat pump in Btu during its normal annual usage period for cooling divided by the total electric energy input in watt-hours during the same period.

EER = Energy Efficiency Ratio: A ratio calculated by dividing the cooling capacity in Btu per hour by the power input in watts at any given set of rating conditions, expressed in Btu per hour per watt.

EF = Efficiency Factor: Efficiency (measured in Btu out / Btu in) of water heaters under certain test conditions specified by the Department of Energy.

kWh/y = Kilowatt hours per year to run the appliance under certain test conditions as specified by the Department of Energy.

Btu = British thermal unit.

N/A = Not applicable.

Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Source: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 22. Commercial Sector Supplement Table

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Commercial Building Delivered										
Energy Consumption (quadrillion Btu) 1/										
Assembly	0.53	0.53	0.53	0.54	0.54	0.55	0.56	0.56	0.57	0.58
Education	0.71	0.72	0.72	0.73	0.73	0.76	0.79	0.79	0.83	0.86
Food Sales	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.19
Food Service	0.39	0.39	0.40	0.40	0.41	0.42	0.44	0.45	0.47	0.49
Health Care	0.55	0.56	0.57	0.58	0.59	0.62	0.66	0.69	0.73	0.78
Lodging	0.55	0.56	0.56	0.57	0.58	0.61	0.64	0.66	0.69	0.73
Office - Large	0.69	0.70	0.71	0.72	0.72	0.76	0.79	0.81	0.84	0.88
Office - Small	0.54	0.55	0.55	0.56	0.56	0.59	0.62	0.62	0.65	0.69
Mercantile/Service	1.13	1.13	1.14	1.15	1.16	1.20	1.24	1.24	1.29	1.35
Warehouse	0.39	0.40	0.40	0.41	0.42	0.44	0.46	0.47	0.50	0.53
Other	0.50	0.51	0.52	0.53	0.54	0.58	0.63	0.66	0.72	0.79
Total	6.15	6.20	6.27	6.34	6.41	6.70	7.00	7.11	7.47	7.85
Commercial Building Floorspace										
(billion square feet)										
Assembly	7.15	7.19	7.24	7.29	7.33	7.49	7.62	7.64	7.82	8.00
Education	8.62	8.74	8.86	8.99	9.11	9.62	10.08	10.24	10.80	11.39
Food Sales	0.71	0.72	0.73	0.74	0.75	0.78	0.81	0.82	0.85	0.89
Food Service	1.47	1.48	1.50	1.51	1.53	1.58	1.63	1.63	1.68	1.74
Health Care	1.85	1.88	1.91	1.94	1.96	2.04	2.13	2.18	2.30	2.42
Lodging	4.15	4.20	4.26	4.33	4.39	4.62	4.84	4.92	5.21	5.52
Office - Large	6.04	6.08	6.11	6.15	6.20	6.42	6.57	6.53	6.70	6.87
Office - Small	5.73	5.77	5.81	5.85	5.90	6.13	6.29	6.27	6.46	6.65
Mercantile/Service	13.98	14.09	14.23	14.38	14.54	15.14	15.66	15.78	16.40	17.05
Warehouse	9.62	9.75	9.87	10.01	10.15	10.63	10.92	10.84	11.32	11.82
Other	5.60	5.72	5.82	5.93	6.04	6.42	6.78	6.98	7.52	8.10
Total	64.93	65.62	66.34	67.11	67.89	70.87	73.32	73.81	77.01	80.35
Stock Avgerage Equipmet Efficiency 2/										
Space Heating										
Electricity	1.10	1.11	1.11	1.12	1.12	1.13	1.13	1.13	1.14	1.16
Natural Gas	0.76	0.76	0.76	0.77	0.77	0.78	0.79	0.80	0.81	0.82
Distillate	0.76	0.76	0.76	0.76	0.76	0.77	0.77	0.77	0.78	0.79
Space Cooling										
Electricity	2.65	2.68	2.72	2.76	2.80	2.93	3.06	3.16	3.34	3.53
Natural Gas	0.95	0.96	0.97	0.99	1.01	1.07	1.12	1.16	1.23	1.31
Water Heating										
Electricity	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97	0.98	0.99
Natural Gas	0.76	0.76	0.77	0.77	0.78	0.79	0.80	0.80	0.82	0.84
Distillate	0.75	0.76	0.76	0.76	0.76	0.77	0.77	0.77	0.78	0.79
Ventilation (cfm per Btu) 3/										
Electricity	0.41	0.41	0.41	0.41	0.41	0.43	0.44	0.45	0.47	0.48
Cooking										
Electricity	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.54
Natural Gas	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lighting Efficacy 4/										
(efficacy in lumens per watt)										
Electricity	51.91	52.68	53.40	53.97	54.54	56.28	57.68	59.53	62.21	65.02
Refrigeration										
Electricity	1.32	1.33	1.33	1.33	1.34	1.35	1.36	1.36	1.37	1.39

1/ Excludes commercial sector energy consumption (from uses such as street lights) that is not attributable to buildings.
2/ Unless noted otherwise, the efficiency measures are in the terms of Btu of energy output divided by Btu of energy input.
3/ The efficiency measure for ventilation is in terms of cubic feet per minute (cfm) of ventilation air delivered divided by Btu of energy input.
4/ A measurement of the ratio of light produced by a light source to the electrical power used to produce that quality of light, expressed in lumens per watt.

Table 22. Commercial Sector Supplement Table

Quad. = Quadrillion.
Btu = British thermal unit.
Avg. = Average.
Equip. = Equipment.
Cfm = Cubic feet per minute.
PC = Personal computer.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 23. Industrial Sector Macroeconomic Indicators

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
GDP (billion 1992 dollars)	8377.2	8595.9	8823.8	9056.3	9250.8	10054.3	11147.2	12178.6	13575.82	15133.34
Non-Agricultural Employment (million)	131.2	132.6	133.9	135.3	136.5	140.1	144.6	147.8	153.24	158.86
Value of Gross Output (billion 1987 dollars)										
Nonmanufacturing Sector										
Agricultural	270.8	273.8	277.3	280.6	283.3	294.6	312.6	329.7	348.51	368.36
Mining	135.8	137.5	138.8	140.6	142.3	148.1	156.6	161.9	168.14	174.60
Construction	473.3	483.0	496.9	510.8	520.3	546.4	597.7	638.9	695.54	757.24
Manufacturing Sector										
Food and Kindred Products	429.9	433.6	437.7	442.6	446.7	462.3	488.9	516.2	544.05	573.34
Tobacco Products	27.2	27.1	26.9	26.7	26.3	25.0	23.8	22.3	21.16	20.07
Textile Mill Products	57.9	58.4	58.5	58.5	58.3	58.8	60.9	62.4	63.41	64.41
Apparel and Other Textile Products	78.6	78.4	77.9	77.4	75.8	72.4	68.4	67.0	63.28	59.78
Lumber and Wood Products	84.5	86.2	87.3	88.6	89.3	90.8	94.6	96.7	101.21	105.93
Furniture and Fixtures	51.0	52.2	52.9	53.5	53.2	54.7	59.4	63.1	67.61	72.47
Paper and Allied Products	136.7	139.1	141.2	143.4	145.1	150.9	158.8	165.6	175.65	186.35
Printing and Publishing	145.6	147.2	148.8	150.4	151.4	155.3	162.1	168.2	174.56	181.12
Chemical and Allied Products	306.9	314.9	320.7	326.5	331.1	352.7	382.4	412.3	447.22	485.09
Bulk Chemicals	160.1	163.6	165.9	168.1	170.1	178.5	189.1	197.8	208.92	220.65
Other Chemicals and Allied Products	146.8	151.2	154.8	158.3	161.0	174.3	193.3	214.5	239.19	266.74
Petroleum and Coal Products	163.3	164.4	167.1	169.7	172.0	176.9	180.1	183.1	189.85	196.80
Petroleum Refining	146.8	147.6	150.1	152.6	154.6	159.0	161.2	163.6	169.36	175.29
Other Petroleum and Coal Products	16.5	16.7	16.9	17.2	17.3	17.9	18.8	19.5	20.50	21.54
Rubber and Miscellaneous Plastic Products	147.3	153.8	159.4	165.1	169.7	189.2	215.3	237.9	271.52	309.94
Leather and Leather Products	5.3	5.1	4.7	4.3	3.9	3.0	2.1	1.5	1.04	0.74
Stone, Clay, and Glass Products	75.0	76.2	77.4	78.6	79.2	80.9	83.8	85.1	88.54	92.09
Glass and Glass Products	20.1	20.5	20.8	21.0	21.2	22.2	23.4	23.7	24.80	25.97
Cement, Hydraulic	5.1	5.1	5.2	5.3	5.3	5.4	5.6	5.7	5.89	6.08
Other Stone, Clay, and Glass Products	49.8	50.5	51.4	52.2	52.6	53.2	54.9	55.7	57.85	60.05
Primary Metals Industry	153.8	156.9	159.4	161.5	161.7	165.0	169.2	171.1	176.36	181.80
Blast Furnace and Basic Steel Products	69.2	70.9	72.3	73.4	73.2	74.5	76.1	77.0	79.23	81.49
Aluminum	30.8	30.9	31.3	31.5	31.6	32.0	32.8	33.3	34.11	34.91
Other Primary Metal Products	53.8	55.0	55.8	56.6	56.8	58.4	60.3	60.7	63.03	65.44
Fabricated Metal Products	198.8	205.7	209.4	213.7	215.9	223.7	236.1	243.3	258.43	274.49
Industrial Machinery and Equipment	379.1	395.3	407.4	421.0	431.4	476.0	544.3	611.2	701.32	804.75
Electronic and Other Electric Equipment	494.8	529.4	559.3	588.7	620.8	741.2	892.4	1027.5	1281.35	1597.89
Transportation Equipment	422.3	443.3	452.7	465.9	473.3	522.6	588.0	636.6	697.83	764.94
Instruments & Related Products	142.9	147.3	151.1	154.8	159.0	177.1	199.5	214.4	240.57	269.94
Miscellaneous Manufacturing Industries	45.5	45.9	46.6	47.2	47.3	48.7	53.2	54.9	57.96	61.18
Total Industrial Gross Output	4426.0	4554.6	4659.5	4769.9	4857.3	5216.4	5730.1	6170.9	6762.14	7410.00

GDP = Gross domestic product.

Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1998: Standard & Poors DRI, Simulation T250899. Projections: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 24. Refining Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollars)	146.78	147.63	150.14	152.56	154.62	159.01	161.25	163.63	169.36	175.29
Energy Consumption (trillion Btu)										
Residual Oil	12.0	12.0	12.0	11.9	25.9	40.6	41.6	43.0	46.30	49.82
Distillate Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liquefied Petroleum Gas	6.2	0.0	0.0	0.0	0.0	15.7	6.9	6.9	5.87	4.99
Petroleum Coke	621.8	612.7	669.9	713.3	735.3	818.5	841.4	838.8	908.91	984.87
Still Gas	1603.4	1602.3	1572.4	1554.1	1548.3	1487.4	1471.4	1463.8	1471.32	1478.91
Other Petroleum 2/	33.9	32.7	32.4	31.6	31.1	15.2	26.0	24.6	23.09	21.64
Petroleum Subtotal	2277.3	2259.7	2286.7	2310.9	2340.6	2377.4	2387.3	2377.1	2444.37	2513.50
Natural Gas	906.2	920.8	930.5	942.2	954.8	971.3	960.0	950.2	961.39	972.69
Steam Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Purchased Electricity	128.1	129.0	128.1	128.2	131.4	128.9	123.2	117.4	118.81	120.28
Total	3311.6	3309.5	3345.3	3381.4	3426.8	3477.6	3470.4	3444.7	3523.84	3604.76
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Residual Oil	0.08	0.08	0.08	0.08	0.17	0.26	0.26	0.26	0.27	0.28
Distillate Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquefied Petroleum Gas	0.04	0.00	0.00	0.00	0.00	0.10	0.04	0.04	0.03	0.03
Petroleum Coke	4.24	4.15	4.46	4.68	4.76	5.15	5.22	5.13	5.37	5.62
Still Gas	10.92	10.85	10.47	10.19	10.01	9.35	9.13	8.95	8.69	8.44
Other Petroleum 2/	0.23	0.22	0.22	0.21	0.20	0.10	0.16	0.15	0.14	0.12
Petroleum Subtotal	15.52	15.31	15.23	15.15	15.14	14.95	14.80	14.53	14.43	14.34
Natural Gas	6.17	6.24	6.20	6.18	6.18	6.11	5.95	5.81	5.68	5.55
Steam Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purchased Electricity	0.87	0.87	0.85	0.84	0.85	0.81	0.76	0.72	0.70	0.69
Total	22.56	22.42	22.28	22.16	22.16	21.87	21.52	21.05	20.81	20.56
Carbon Emissions (billion kilograms)	57.3	57.3	57.7	58.1	59.0	59.3	59.0	58.4	59.60	60.84

1/ Fuel consumption includes consumption for cogeneration.
2/ Includes lubricants and miscellaneous petroleum products.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 25. Food Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollars)	429.94	433.59	437.69	442.61	446.68	462.30	488.87	516.25	544.05	573.34
Energy Consumption (trillion Btu)										
Residual Oil	26.2	26.4	26.7	27.1	27.5	28.2	29.5	30.9	32.04	33.18
Distillate Oil	19.4	19.6	19.9	20.2	20.4	20.9	21.8	22.8	23.51	24.23
Liquefied Petroleum Gas	5.2	5.2	5.4	5.5	5.6	5.7	5.9	6.2	6.36	6.54
Other Petroleum 2/	94.8	96.1	97.7	99.7	101.5	106.7	115.1	124.3	132.87	142.06
Petroleum Subtotal	145.5	147.4	149.6	152.5	155.0	161.6	172.3	184.2	194.64	205.68
Natural Gas	682.0	684.3	686.4	689.3	691.2	704.1	739.3	778.7	810.09	842.72
Steam Coal	158.6	158.9	159.3	159.8	160.2	161.3	162.6	164.4	166.17	167.95
Renewables	13.1	13.2	13.3	13.5	13.6	14.1	15.0	15.9	16.88	17.88
Purchased Electricity	220.2	222.1	224.2	227.1	229.1	236.4	249.3	263.8	277.84	292.67
Total	1219.3	1225.8	1232.9	1242.1	1249.2	1277.5	1338.5	1407.0	1464.97	1525.31
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Residual Oil	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Distillate Oil	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04
Liquefied Petroleum Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other Petroleum 2/	0.22	0.22	0.22	0.23	0.23	0.23	0.24	0.24	0.24	0.25
Petroleum Subtotal	0.34	0.34	0.34	0.34	0.35	0.35	0.35	0.36	0.36	0.36
Natural Gas	1.59	1.58	1.57	1.56	1.55	1.52	1.51	1.51	1.49	1.47
Steam Coal	0.37	0.37	0.36	0.36	0.36	0.35	0.33	0.32	0.31	0.29
Renewables	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Purchased Electricity	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Total	2.84	2.83	2.82	2.81	2.80	2.76	2.74	2.73	2.69	2.66
Carbon Emissions (billion kilograms)	28.1	28.4	28.6	28.8	29.0	29.6	31.0	32.6	34.05	35.60

1/ Fuel consumption includes consumption for cogeneration.
2/ Includes petroleum coke, lubricants, and miscellaneous petroleum products.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 26. Paper Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollar)	136.66	139.09	141.24	143.41	145.05	150.89	158.78	165.56	175.65	186.35
Energy Consumption (trillion Btu)										
Residual Oil	153.3	154.6	156.0	157.8	158.9	158.7	160.9	166.7	168.39	170.14
Distillate Oil	11.7	11.8	12.0	12.1	12.2	12.3	12.5	13.0	13.20	13.41
Liquefied Petroleum Gas	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.18	4.28
Other Petroleum 2/	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Subtotal	168.6	170.1	171.7	173.7	175.0	174.9	177.4	183.7	185.77	187.83
Natural Gas	670.8	674.8	676.0	676.7	674.3	665.3	671.6	693.1	703.77	714.62
Steam Coal	298.3	296.3	294.3	292.4	290.5	282.9	277.2	276.6	270.33	264.21
Renewables	1458.5	1482.7	1504.6	1526.8	1543.6	1604.2	1684.8	1753.4	1853.39	1959.12
Purchased Electricity	265.6	268.8	271.7	274.9	277.0	284.1	295.6	308.5	322.92	338.03
Total	2861.8	2892.6	2918.3	2944.5	2960.4	3011.4	3106.5	3215.3	3330.23	3449.29
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Residual Oil	1.12	1.11	1.10	1.10	1.10	1.05	1.01	1.01	0.96	0.91
Distillate Oil	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07
Liquefied Petroleum Gas	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
Other Petroleum 2/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum Subtotal	1.23	1.22	1.22	1.21	1.21	1.16	1.12	1.11	1.06	1.01
Natural Gas	4.91	4.85	4.79	4.72	4.65	4.41	4.23	4.19	4.01	3.83
Steam Coal	2.18	2.13	2.08	2.04	2.00	1.87	1.75	1.67	1.54	1.42
Renewables	10.67	10.66	10.65	10.65	10.64	10.63	10.61	10.59	10.55	10.51
Purchased Electricity	1.94	1.93	1.92	1.92	1.91	1.88	1.86	1.86	1.84	1.81
Total	20.94	20.80	20.66	20.53	20.41	19.96	19.56	19.42	18.96	18.51
Carbon Emissions (billion kilograms)	34.5	34.8	34.9	35.1	35.1	34.9	35.6	36.6	37.41	38.21

1/ Fuel consumption includes consumption for cogeneration.
2/ Includes petroleum coke, lubricants, and miscellaneous petroleum products.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO99 National Energy Modeling System run AEO2000.D100198A.

Table 27. Bulk Chemical Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion1987 dollars)	160.07	163.61	165.88	168.14	170.09	178.46	189.06	197.83	208.92	220.65
Energy Consumption (trillion Btu)										
Heat and Power										
Residual Oil	51.2	52.3	53.2	54.3	55.3	58.2	61.6	64.6	67.50	70.52
Distillate Oil	5.8	5.9	6.0	6.1	6.2	6.4	6.7	6.9	7.01	7.11
Liquefied Petroleum Gas	1.7	1.8	1.8	1.9	1.9	2.0	2.1	2.2	2.29	2.38
Other Petroleum 2/	470.8	481.3	489.9	500.3	510.0	538.6	573.6	606.9	640.79	676.58
Petroleum Subtotal	529.5	541.2	550.9	562.5	573.4	605.2	644.0	680.6	717.53	756.46
Natural Gas	1833.4	1865.0	1879.0	1889.9	1897.5	1947.8	2027.6	2103.9	2181.42	2261.79
Steam Coal	208.3	208.4	208.6	208.8	209.1	209.8	210.4	211.2	212.18	213.14
Purchased Electricity	492.2	506.0	515.5	525.8	534.0	566.7	609.2	647.5	694.91	745.75
Total Heat and Power	3063.4	3120.6	3154.0	3187.0	3214.0	3329.5	3491.2	3643.3	3803.31	3970.38
Feedstock										
Liquefied Petroleum Gas	1663.8	1697.8	1718.9	1740.1	1758.3	1836.9	1937.1	2019.2	2121.31	2228.60
Petrochemical Feedstocks	1344.4	1371.8	1388.9	1406.0	1420.7	1484.2	1565.2	1631.5	1714.03	1800.72
Natural Gas	732.8	747.8	757.1	766.4	774.4	809.0	853.2	889.3	934.31	981.57
Total Feedstocks	3741.0	3817.3	3864.8	3912.5	3953.4	4130.1	4355.4	4540.0	4769.65	5010.88
Total	6804.4	6937.9	7018.8	7099.6	7167.4	7459.6	7846.5	8183.3	8572.73	8980.69
Consumption per Unit of Output										
(thousand Btu per 1987 dollar of output)										
Heat and Power										
Residual Oil	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.32	0.32
Distillate Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.03
Liquefied Petroleum Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01
Other Petroleum	2.9	2.9	3.0	3.0	3.0	3.0	3.0	3.1	3.07	3.07
Petroleum Subtotal	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.4	3.43	3.43
Natural Gas 2/	11.5	11.4	11.3	11.2	11.2	10.9	10.7	10.6	10.44	10.25
Steam Coal	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.02	0.97
Purchased Electricity	3.1	3.1	3.1	3.1	3.1	3.2	3.2	3.3	3.33	3.38
Total Heat and Power	19.1	19.1	19.0	19.0	18.9	18.7	18.5	18.4	18.20	17.99
Feedstock										
Liquefied Petroleum Gas	10.4	10.4	10.4	10.3	10.3	10.3	10.2	10.2	10.15	10.10
Petrochemical Feedstocks	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.2	8.20	8.16
Natural Gas 2/	4.6	4.6	4.6	4.6	4.6	4.5	4.5	4.5	4.47	4.45
Total Feedstocks	23.4	23.3	23.3	23.3	23.2	23.1	23.0	22.9	22.83	22.71
Total	42.5	42.4	42.3	42.2	42.1	41.8	41.5	41.4	41.03	40.70
Carbon Emissions (billion kilograms)	86.8	88.7	89.9	91.0	92.0	95.5	100.9	105.5	111.11	116.96

1/ Fuel consumption includes consumption for cogeneration.
2/ Includes petroleum coke, lubricants, and miscellaneous petroleum products.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 28. Glass Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollars)	20.07	20.48	20.79	21.04	21.24	22.25	23.39	23.68	24.80	25.97
Energy Consumption (trillion Btu)										
Residual Oil	4.6	4.7	4.8	4.9	5.0	5.2	5.3	5.3	5.36	5.44
Distillate Oil	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.6	0.64	0.63
Liquefied Petroleum Gas	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.58	0.59
Petroleum Subtotal	5.6	5.8	5.9	6.0	6.1	6.3	6.5	6.5	6.57	6.66
Natural Gas	171.2	173.3	174.5	175.1	175.4	178.6	182.3	180.8	183.58	186.39
Purchased Electricity	34.0	34.7	35.3	35.8	36.1	37.6	39.1	39.4	41.08	42.84
Total	210.9	213.8	215.6	216.9	217.6	222.5	227.8	226.7	231.16	235.74
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Residual Oil	0.23	0.23	0.23	0.23	0.24	0.23	0.22	0.22	0.22	0.21
Distillate Oil	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Liquefied Petroleum Gas	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Petroleum Subtotal	0.28	0.28	0.28	0.29	0.29	0.28	0.28	0.27	0.27	0.26
Natural Gas	8.53	8.46	8.39	8.32	8.26	8.03	7.79	7.64	7.40	7.18
Purchased Electricity	1.70	1.70	1.70	1.70	1.70	1.69	1.67	1.66	1.66	1.65
Total	10.51	10.44	10.37	10.31	10.25	10.00	9.74	9.57	9.32	9.08
Carbon Emissions (billion kilograms)	4.3	4.4	4.5	4.5	4.5	4.6	4.8	4.7	4.89	5.03

1/ Fuel consumption includes consumption for cogeneration.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 29. Cement Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollars)	5.08	5.14	5.21	5.29	5.32	5.41	5.57	5.71	5.89	6.08
Energy Consumption (trillion Btu)										
Residual Oil	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.0	0.93	0.85
Distillate Oil	2.6	2.6	2.6	2.6	2.5	2.4	2.3	2.2	1.96	1.75
Other Petroleum 2/	73.7	74.2	74.6	75.3	75.2	74.6	74.6	74.9	75.14	75.39
Petroleum Subtotal	77.6	78.0	78.4	79.0	78.9	78.1	78.0	78.1	77.92	77.76
Natural Gas	24.8	24.5	23.9	23.3	22.7	21.0	19.9	18.9	17.35	15.96
Steam Coal	263.6	265.1	267.0	269.6	269.8	267.6	266.9	268.4	269.85	271.32
Purchased Electricity	48.6	49.1	49.7	50.4	50.5	50.8	51.7	52.5	53.63	54.81
Total	414.5	416.6	419.0	422.4	421.9	417.5	416.5	417.8	418.27	418.74
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Residual Oil	0.24	0.24	0.23	0.23	0.22	0.21	0.19	0.18	0.16	0.14
Distillate Oil	0.52	0.50	0.49	0.48	0.48	0.44	0.41	0.38	0.33	0.29
Other Petroleum 2/	14.53	14.43	14.32	14.22	14.13	13.81	13.39	13.12	12.75	12.39
Petroleum Subtotal	15.28	15.17	15.05	14.93	14.83	14.45	14.00	13.68	13.22	12.78
Natural Gas	4.89	4.76	4.59	4.41	4.26	3.89	3.58	3.31	2.95	2.62
Steam Coal	51.92	51.57	51.26	50.94	50.68	49.50	47.90	47.03	45.80	44.59
Purchased Electricity	9.57	9.55	9.53	9.52	9.50	9.40	9.28	9.20	9.10	9.01
Total	81.66	81.05	80.43	79.80	79.27	77.24	74.76	73.22	70.99	68.82
Carbon Emissions (billion kilograms)	11.1	11.2	11.3	11.4	11.4	11.3	11.3	11.3	11.40	11.48

1/ Fuel consumption includes consumption for cogeneration.
2/ Includes petroleum coke, lubricants, and miscellaneous petroleum products.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 30. Iron and Steel Industries Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollars)	69.16	70.94	72.34	73.39	73.22	74.54	76.10	77.03	79.23	81.49
Energy Consumption (trillion Btu)										
Residual Oil	41.5	42.4	43.1	43.8	43.6	42.7	41.5	41.0	40.14	39.31
Other Petroleum 2/	48.8	50.2	51.2	51.8	51.0	49.4	47.3	45.3	43.81	42.33
Petroleum Subtotal	90.2	92.6	94.4	95.6	94.6	92.0	88.9	86.3	83.94	81.62
Natural Gas	489.3	494.6	497.7	498.3	493.8	489.3	487.9	486.8	484.89	483.02
Metallurgical Coal	741.3	728.3	715.6	703.1	690.8	643.6	589.0	540.4	495.02	453.44
Net Coke Imports	124.0	141.3	156.4	169.2	174.0	205.3	241.7	273.2	351.81	452.99
Steam Coal	86.2	87.1	88.2	89.3	89.4	90.4	91.3	92.6	94.85	97.14
Coal Subtotal	951.5	956.8	960.2	961.6	954.2	939.3	921.9	906.3	892.72	879.40
Purchased Electricity	165.8	171.4	176.1	180.1	179.9	184.7	190.2	195.0	203.56	212.46
Total	1696.8	1715.4	1728.5	1735.7	1722.4	1705.3	1688.9	1674.4	1663.61	1652.91
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Residual Oil	0.60	0.60	0.60	0.60	0.60	0.57	0.55	0.53	0.51	0.48
Other Petroleum 2/	0.71	0.71	0.71	0.71	0.70	0.66	0.62	0.59	0.55	0.52
Petroleum Subtotal	1.30	1.30	1.30	1.30	1.29	1.23	1.17	1.12	1.06	1.00
Natural Gas	7.07	6.97	6.88	6.79	6.74	6.56	6.41	6.32	6.12	5.93
Metallurgical Coal	10.72	10.27	9.89	9.58	9.44	8.63	7.74	7.02	6.25	5.56
Net Coke Imports	1.79	1.99	2.16	2.31	2.38	2.75	3.18	3.55	4.44	5.56
Steam Coal	1.25	1.23	1.22	1.22	1.22	1.21	1.20	1.20	1.20	1.19
Coal Subtotal	13.76	13.49	13.27	13.10	13.03	12.60	12.11	11.76	11.27	10.79
Purchased Electricity	2.40	2.42	2.43	2.45	2.46	2.48	2.50	2.53	2.57	2.61
Total	24.53	24.18	23.89	23.65	23.52	22.88	22.19	21.74	21.00	20.28
Carbon Emissions (billion kilograms)	41.5	42.1	42.6	42.8	42.5	42.1	41.9	41.7	41.69	41.69

1/ Fuel consumption includes consumption for cogeneration.
2/ Includes petroleum coke, lubricants, and miscellaneous petroleum products.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 31. Aluminum Industry Energy Consumption

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Industry Output (billion 1987 dollars)	30.78	30.92	31.26	31.55	31.64	32.00	32.82	33.34	34.11	34.91
Energy Consumption (trillion Btu)										
Distillate Oil	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.14	0.14
Liquefied Petroleum Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01
Petroleum Coke	14.2	14.2	14.2	14.3	14.3	14.2	14.3	14.4	14.48	14.53
Other Petroleum	30.9	30.9	31.1	31.3	31.2	31.0	31.2	31.2	31.33	31.42
Petroleun Subtotal	45.2	45.2	45.5	45.7	45.6	45.4	45.6	45.8	45.96	46.11
Natural Gas	82.3	82.3	82.6	82.9	82.7	81.9	82.3	82.6	82.68	82.72
Purchased Electricity	217.1	217.5	219.4	220.8	220.8	221.2	224.6	226.8	229.40	232.02
Total	344.7	345.0	347.5	349.3	349.1	348.5	352.5	355.3	358.01	360.80
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)										
Distillate Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquefied Petroleum Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum Coke	0.46	0.46	0.46	0.45	0.45	0.44	0.44	0.43	0.42	0.42
Other Petroleum	1.00	1.00	1.00	0.99	0.99	0.97	0.95	0.94	0.92	0.90
Petroleun Subtotal	1.47	1.46	1.46	1.45	1.44	1.42	1.39	1.37	1.35	1.32
Natural Gas	2.67	2.66	2.64	2.63	2.61	2.56	2.51	2.48	2.42	2.37
Purchased Electricity	7.05	7.04	7.02	7.00	6.98	6.91	6.84	6.80	6.72	6.65
Total	11.20	11.16	11.11	11.07	11.03	10.89	10.74	10.66	10.49	10.34
Carbon Emissions (billion kilograms)	13.2	13.3	13.4	13.5	13.5	13.3	13.5	13.6	13.80	14.01

1/ Fuel consumption includes consumption for cogeneration.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 32. Other Industrial Sector Energy Consumption
(Trillion Btu)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Agriculture										
Distillate Oil	594.2	601.3	609.6	617.5	624.1	652.4	695.8	736.3	782.34	831.21
Liquid Petroleum Gas	82.0	83.0	84.1	85.2	86.1	90.1	96.1	101.7	108.02	114.77
Motor Gasoline	97.3	98.5	99.9	101.2	102.3	106.9	114.0	120.7	128.20	136.21
Other Petroleum	17.3	17.5	17.8	18.0	18.2	19.0	20.3	21.4	22.77	24.19
Petroleum Subtotal	790.8	800.3	811.4	821.9	830.7	868.3	926.2	980.1	1041.32	1106.38
Natural Gas	51.5	52.1	52.9	53.6	54.1	56.6	60.4	64.0	68.04	72.34
Steam Coal	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.53	0.55
Renewables	20.5	20.7	21.0	21.3	21.6	22.6	24.1	25.5	27.14	28.88
Purchased Electricity	141.7	143.4	145.4	147.3	148.8	155.5	165.9	175.5	186.44	198.06
Total	1005.0	1017.1	1031.1	1044.6	1055.7	1103.5	1177.1	1245.6	1323.48	1406.20
Industry Output (billion 1987 dollars)	270.80	273.83	277.27	280.58	283.30	294.55	312.61	329.73	348.51	368.36
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of outp	3.71	3.71	3.72	3.72	3.73	3.75	3.77	3.78	3.80	3.82
Carbon Emissions (billion kilograms)	23.4	23.7	24.1	24.4	24.6	25.6	27.4	28.9	30.78	32.76
Construction										
Distillate Oil	205.7	209.7	215.5	221.2	225.1	235.7	256.9	273.8	296.89	321.89
Motor Gasoline	126.5	129.0	132.5	136.0	138.4	145.0	158.0	168.4	182.61	197.99
Asphalt and Road Oil	1403.3	1429.8	1468.5	1507.0	1533.8	1607.9	1753.3	1873.3	2030.58	2201.02
Petroleum Subtotal	1735.5	1768.6	1816.5	1864.2	1897.3	1988.6	2168.2	2315.6	2510.08	2720.90
Natural Gas	205.3	209.2	215.0	220.7	224.6	235.2	256.3	273.2	296.19	321.13
Steam Coal	154.4	157.4	161.7	166.0	169.0	176.9	192.8	205.5	222.84	241.61
Purchased Electricity	133.5	136.1	139.9	143.6	146.1	153.0	166.7	177.7	192.66	208.87
Total	2228.7	2271.3	2333.0	2394.5	2436.9	2553.7	2784.1	2972.0	3221.77	3492.51
Industry Output (billion 1987 dollars)	473.27	483.01	496.95	510.78	520.31	546.37	597.73	638.86	695.54	757.24
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of outp	4.71	4.70	4.69	4.69	4.68	4.67	4.66	4.65	4.63	4.61
Carbon Emissions (billion kilograms)	20.2	20.7	21.3	21.8	22.2	23.1	25.2	26.8	29.17	31.68
Mining										
Residual Oil	25.8	26.2	26.5	26.8	27.0	27.7	28.6	29.3	30.27	31.29
Distillate Oil	177.4	180.4	182.8	184.7	186.2	190.5	197.2	201.9	208.70	215.74
Motor Gasoline	14.0	14.1	14.2	14.3	14.5	15.1	16.0	16.6	17.15	17.74
Other Petroleum	7.5	7.5	7.5	7.6	7.8	8.2	8.8	9.2	9.49	9.83
Petroleum Subtotal	224.6	228.2	231.0	233.5	235.5	241.5	250.6	256.9	265.61	274.61
Natural Gas	340.4	342.0	343.0	347.4	352.6	372.2	399.6	414.8	429.13	443.93
Lease and Plant Fuel	1253.40	1267.77	1275.82	1298.77	1332.72	1466.72	1613.93	1712.70	1831.36	1958.24
Steam Coal	96.9	98.7	100.0	101.0	101.6	103.1	105.1	106.1	109.27	112.53
Renewables	1.1	1.1	1.1	1.1	1.1	1.2	1.3	1.3	1.35	1.40
Purchased Electricity	293.2	297.5	300.8	304.5	307.6	317.9	332.7	341.5	353.54	365.99
Total	2209.6	2235.1	2251.6	2286.2	2331.1	2502.6	2703.2	2833.4	2988.08	3151.26
Industry Output (billion 1987 dollars)	135.81	137.50	138.83	140.57	142.29	148.13	156.59	161.91	168.14	174.60
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of outp	16.27	16.26	16.22	16.26	16.38	16.89	17.26	17.50	17.77	18.05
Carbon Emissions (billion kilograms)	27.0	27.4	27.7	28.0	28.3	29.0	30.4	31.2	32.39	33.61
Metal-Based Durables Consumption										
Residual Oil	33.0	34.9	36.4	38.1	39.7	45.6	52.8	58.2	67.50	78.32
Distillate Oil	22.1	23.4	24.4	25.5	26.6	30.2	34.7	38.4	43.72	49.83
Liquid Petroleum Gas	4.2	4.5	4.7	4.9	5.2	5.8	6.7	7.3	8.30	9.40
Other Petroleum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Subtotal	59.4	62.8	65.4	68.6	71.4	81.6	94.2	103.8	119.48	137.47
Natural Gas	859.3	899.2	925.8	954.5	979.3	1087.8	1232.2	1348.5	1526.34	1727.62
Steam Coal	83.3	83.4	83.4	83.5	83.6	83.9	84.3	84.6	85.01	85.38
Renewables	1.0	1.0	1.1	1.1	1.1	1.2	1.4	1.5	1.69	1.90
Purchased Electricity	667.4	698.9	721.2	746.0	766.5	852.8	965.6	1061.2	1205.78	1370.07
Total	1670.4	1745.4	1796.9	1853.7	1902.0	2107.3	2377.5	2599.7	2933.97	3311.22
Industry Output (billion 1987 dollars)	1637.83	1720.99	1779.92	1844.13	1900.41	2140.73	2460.26	2732.99	3149.87	3630.34
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of outp	1.02	1.01	1.01	1.01	1.00	0.98	0.97	0.95	0.93	0.91

Table 32. Other Industrial Sector Energy Consumption
(Trillion Btu)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Carbon Emissions (billion kilograms)	50.1	52.6	54.3	56.0	57.4	63.0	71.2	77.9	88.37	100.29
Other Manufacturing Consumption										
Residual Oil	44.3	45.2	46.1	47.1	47.9	50.1	52.9	55.3	57.50	59.76
Distillate Oil	51.0	52.3	53.7	55.2	56.3	59.0	63.2	66.4	68.66	71.04
Liquid Petroleum Gas	16.3	16.7	17.1	17.7	18.2	19.2	20.6	21.7	23.12	24.60
Petroleum Subtotal	111.6	114.2	116.9	120.0	122.5	128.3	136.7	143.4	149.24	155.32
Natural Gas	1738.2	1769.4	1791.9	1812.2	1821.2	1880.3	1987.9	2079.1	2185.88	2298.17
Steam Coal	157.6	159.2	160.3	161.3	161.7	164.0	168.0	171.0	174.92	178.89
Renewables	318.7	325.3	330.4	335.5	338.2	352.4	376.5	397.6	422.69	449.32
Purchased Electricity	779.5	794.9	807.3	820.3	826.7	858.4	911.9	959.5	1015.93	1075.64
Total	3105.6	3162.9	3206.8	3249.3	3270.2	3383.3	3580.9	3750.7	3947.98	4155.64
Industry Output (billion 1987 dollars)	909.72	927.81	941.95	955.82	963.16	1001.73	1067.03	1124.40	1191.51	1262.63
Energy Consumption per Unit of Output (thousand Btu per 1987 dollar of output)	3.41	3.41	3.40	3.40	3.40	3.38	3.36	3.34	3.31	3.29
Carbon Emissions (billion kilograms)	71.5	73.0	74.2	75.1	75.6	77.6	82.3	86.1	91.03	96.21

Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 33. Transportation Sector Energy Use by Mode and Type (Trillion Btu)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Energy Use by Mode										
Highway										
Light-Duty Vehicles	16010.2	16278.9	16640.7	16966.2	17302.8	18536.6	19867.1	21027.1	22830.29	24788.06
Automobiles	7706.6	7615.2	7573.3	7516.1	7473.4	7336.1	7275.9	7393.9	7273.50	7155.00
Light Trucks	8282.4	8641.2	9045.1	9428.6	9811.7	11181.0	12570.1	13611.3	16006.87	18824.02
Motorcycles	22.1	21.9	21.8	21.6	21.5	21.1	20.9	21.2	20.88	20.54
Commercial Light Trucks 1/	642.3	652.3	662.8	673.1	681.6	714.0	757.4	793.2	841.13	891.93
Buses	153.2	153.5	154.1	154.4	154.7	155.1	153.9	152.0	152.15	152.26
Transit	73.8	73.9	74.2	74.4	74.5	74.7	74.1	73.2	73.27	73.33
Intercity	20.0	20.1	20.2	20.2	20.2	20.3	20.1	19.9	19.91	19.92
School	59.4	59.5	59.7	59.9	60.0	60.1	59.7	58.9	58.97	59.01
Freight Trucks 2/	4414.2	4493.8	4562.5	4627.5	4668.0	4789.9	4939.7	5025.9	5252.36	5489.03
Medium (1000-26000 pounds)	810.1	808.4	803.5	800.5	799.2	806.8	834.9	866.4	868.71	870.98
Large (> 26000 pounds)	3604.0	3685.4	3759.0	3827.0	3868.8	3983.1	4104.8	4159.4	4389.14	4631.53
Non-Highway										
Air 3/	3520.1	3662.6	3812.9	3946.9	4100.9	4656.6	5386.1	6124.8	7155.06	8358.65
General Aviation	200.1	206.5	213.3	219.3	226.3	251.4	284.4	317.9	361.33	410.69
Domestic Air Carriers	1929.4	2000.1	2052.4	2101.4	2143.5	2311.4	2533.8	2762.2	3060.05	3389.97
International Air Carriers	855.5	876.2	919.5	943.2	996.9	1125.9	1294.3	1466.4	1719.05	2015.19
Freight Carriers	535.1	579.7	627.7	682.9	734.2	967.9	1273.5	1578.2	2131.97	2880.01
Water 4/	1247.2	1274.4	1304.4	1336.5	1366.5	1490.9	1646.2	1796.5	1983.78	2190.55
Freight	989.2	1014.4	1042.1	1072.1	1100.0	1216.3	1361.4	1501.6	1682.45	1885.05
Domestic Shipping	278.5	279.0	278.8	279.3	279.1	277.1	276.3	270.8	267.94	265.10
International Shipping	710.7	735.4	763.2	792.8	820.9	939.2	1085.1	1230.8	1434.87	1672.77
Recreational Boats	258.1	260.0	262.3	264.4	266.5	274.6	284.9	294.9	305.95	317.40
Rail	581.3	585.0	591.2	595.0	601.0	609.2	623.7	636.8	656.09	676.02
Freight	471.4	473.1	477.2	479.1	483.2	483.5	488.2	491.0	499.24	507.64
Passenger	109.9	112.0	114.0	115.9	117.8	125.7	135.6	145.8	158.11	171.48
Intercity	20.9	21.2	21.6	22.0	22.3	23.8	25.7	27.7	30.00	32.55
Transit	47.9	48.8	49.7	50.5	51.3	54.8	59.1	63.5	68.86	74.67
Commuter	41.2	41.9	42.7	43.4	44.1	47.1	50.8	54.6	59.24	64.27
Lubricants	273.1	275.0	278.2	282.9	287.0	297.7	313.7	325.9	343.50	362.03
Pipeline Fuel Natural Gas	745.8	751.9	754.4	767.8	788.9	866.4	948.1	987.9	1051.32	1118.77
Military Use	521.6	518.3	516.7	520.0	525.4	542.2	548.9	556.9	565.33	573.89
Aviation	454.7	451.8	450.4	453.3	458.0	472.7	478.5	485.5	492.65	499.95
Residual Fuel Use	8.1	8.0	8.0	8.1	8.2	8.4	8.5	8.6	8.86	9.08
Distillate Fuel Use	58.8	58.4	58.3	58.6	59.2	61.1	61.9	62.8	63.82	64.86
Total	28108.9	28645.8	29277.7	29870.3	30476.8	32658.7	35184.8	37427.1	40698.34	44255.49
Energy Use by Type										
Motor Gasoline	16817.6	17043.8	17369.0	17654.3	17958.5	19059.5	20208.7	21231.9	22776.22	24432.89
Distillate (diesel)	5273.7	5364.5	5448.6	5530.2	5582.6	5757.3	6023.0	6224.0	6557.70	6909.34
Jet Fuel (kerosene & naptha)	3766.4	3899.2	4041.0	4171.5	4322.9	4866.9	5567.4	6277.8	7237.59	8344.10
Residual Oil	725.7	747.8	772.5	799.0	824.1	929.2	1059.0	1187.3	1361.54	1561.33
Aviation Gasoline	42.4	42.3	42.3	42.3	42.2	42.1	42.1	42.1	41.92	41.76
Liquid Petroleum Gas	68.5	74.8	80.8	86.3	91.1	106.9	123.0	132.8	169.79	217.07
Lubricants	273.1	275.0	278.2	282.9	287.0	297.7	313.7	325.9	343.50	362.03
Oil Subtotal	26967.3	27447.5	28032.5	28566.5	29108.4	31059.6	33336.9	35421.8	38379.96	41585.22
Methanol	40.1	50.7	55.1	63.3	72.1	101.0	132.0	152.0	296.26	577.62
Ethanol	17.4	22.0	27.2	32.4	37.7	57.1	73.7	79.4	169.05	360.00
Electricity	74.2	81.7	89.0	95.7	101.8	124.0	149.5	168.1	206.68	254.12
Compressed Natural Gas	98.1	119.2	139.6	158.1	174.2	230.4	289.5	327.6	604.42	1115.08
Liquid Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pipeline Fuel Natural Gas	745.8	751.9	754.4	767.8	788.9	866.4	948.1	987.9	1051.32	1118.77
Total Consumption	27942.9	28473.0	29097.8	29683.9	30283.1	32438.4	34929.7	37136.8	40362.86	43869.22

1/ Commercial light trucks from 8,500 to 10,000 pounds.
2/ Does not include commercial bus and military use.
3/ Does not include military jet fuel use.
4/ Does not include military residual oil.
Btu = British thermal unit.

Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1998 values derived using: Energy Infornation Administration (EIA), Short-Term Energy Outlook, September 1999, Online. http:/www.eia.doe.gov/pub/forecasting/steo/oldsteos/sep99.html (October 12, 1999); EIA, Fuel Oil and Kerosene Sales 1997, DOE/EIA-0535(97) (Washington, D.C., August 1998); EIA, State Energy Data Report 1996, DOE/EIA-0214(96) (Washington, DC, Febuary 1999); Oak Ridge National Laboratory, Transportation Energy Book: 17 and 18 (September 1998); Department of Defense, Defense Fuel Supply Center; and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 34. Transportation Sector Energy Use by Fuel Type Within a Mode
(Trillion Btu per Year)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Light-Duty Vehicle										
Motor Gasoline	15646.60	15877.02	16203.42	16488.80	16793.74	17890.77	19016.85	20013.15	21578.62	23266.55
Methanol	40.09	50.67	55.12	63.29	72.07	100.96	131.99	151.95	296.26	577.62
Ethanol	17.44	21.98	27.15	32.42	37.73	57.10	73.67	79.38	169.05	360.00
Compressed Natural Gas	94.36	114.28	133.15	149.69	163.39	206.87	249.62	277.50	506.31	923.76
Liquid Petroleum Gas	49.69	56.03	62.13	67.49	71.98	86.44	100.63	109.31	153.63	215.93
Electricity	1.77	7.97	13.91	19.35	24.18	41.13	60.19	72.04	228.90	727.24
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distillate (diesel)	160.20	150.93	145.78	145.12	139.70	153.39	234.17	323.81	354.58	388.27
Total	16010.15	16278.89	16640.66	16966.16	17302.79	18536.65	19867.11	21027.15	22830.29	24788.06
Commercial Light Trucks Gasoline 1/	642.33	652.28	662.80	673.12	681.61	714.04	757.35	793.22	841.13	891.93
Freight Trucks 2/										
Motor Gasoline	263.25	247.16	233.14	220.54	209.23	172.69	142.30	123.32	97.30	76.77
Distillate (diesel)	4128.42	4223.02	4304.24	4379.73	4428.92	4573.18	4735.09	4828.95	5109.37	5406.08
Compressed Natural Gas	3.71	4.89	6.46	8.45	10.83	23.58	39.93	50.12	99.54	197.70
Liquid Petroleum Gas	18.79	18.77	18.66	18.80	19.08	20.45	22.33	23.49	24.20	24.93
Total	4414.16	4493.84	4562.49	4627.51	4668.05	4789.90	4939.66	5025.89	5252.36	5489.03
Freight Rail 3/										
Distillate (diesel)	471.36	473.06	477.25	479.10	483.22	483.54	488.17	490.98	499.24	507.64
Total	471.36	473.06	477.25	479.10	483.22	483.54	488.17	490.98	499.24	507.64
Domestic Shipping										
Distillate (diesel)	194.15	194.54	194.39	194.69	194.58	193.18	192.64	188.81	186.36	183.94
Residual Oil	84.32	84.49	84.43	84.56	84.51	83.90	83.67	82.00	81.59	81.18
Motor Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	278.47	279.03	278.82	279.25	279.09	277.09	276.30	270.82	267.94	265.10
International Shipping										
Distillate (diesel)	77.47	80.16	83.19	86.42	89.48	102.37	118.27	134.16	156.40	182.32
Residual Oil	633.23	655.26	680.05	706.41	731.46	836.85	966.78	1096.65	1278.48	1490.45
Total	710.70	735.42	763.25	792.83	820.94	939.23	1085.05	1230.81	1434.87	1672.77
Air Transportation										
Jet Fuel	3311.73	3447.43	3590.64	3718.25	3864.95	4394.21	5088.89	5792.36	6777.57	7930.35
Aviation Gasoline	42.41	42.35	42.30	42.26	42.23	42.14	42.10	42.08	41.92	41.76
Total	3354.14	3489.78	3632.94	3760.51	3907.17	4436.35	5130.99	5834.43	6815.33	7961.14
Miscellaneous Transportation										
Military Use										
Jet Fuel	454.65	451.78	450.38	453.27	458.00	472.66	478.53	485.46	492.65	499.95
Residual Fuel	8.10	8.05	8.02	8.08	8.16	8.42	8.53	8.65	8.86	9.08
Distillate	58.81	58.44	58.25	58.63	59.24	61.14	61.89	62.79	63.82	64.86
Total	521.56	518.27	516.66	519.97	525.40	542.22	548.95	556.90	565.33	573.89
Bus Transportation										
Transit Bus (motor gasoline)	4.07	4.08	4.09	4.10	4.11	4.12	4.09	4.04	4.03	4.03
Transit Bus (diesel)	69.70	69.87	70.11	70.27	70.41	70.59	70.05	69.18	69.24	69.30
Intercity Bus (diesel)	20.04	20.09	20.16	20.20	20.24	20.29	20.14	19.89	19.91	19.92
School Bus (motor gasoline)	3.27	3.28	3.29	3.30	3.31	3.31	3.29	3.25	3.24	3.24
School Bus (diesel)	56.10	56.23	56.42	56.55	56.66	56.81	56.38	55.68	55.73	55.77
Total	153.18	153.54	154.07	154.42	154.73	155.12	153.94	152.04	152.15	152.26
Rail Transportation										
Intercity Rail (electicity)	8.25	8.40	8.55	8.70	8.84	9.43	10.18	10.94	11.87	12.87
Intercity Rail (diesel)	12.60	12.83	13.06	13.28	13.50	14.41	15.54	16.71	18.14	19.68
Transit Rail (electricity)	47.89	48.78	49.65	50.48	51.31	54.75	59.06	63.51	68.86	74.67
Commuter Rail (electricity)	16.29	16.60	16.89	17.18	17.46	18.63	20.10	21.61	23.43	25.40
Commuter Rail (diesel)	24.88	25.34	25.80	26.23	26.66	28.45	30.69	33.00	35.81	38.87
Total	109.92	111.95	113.96	115.87	117.77	125.67	135.57	145.77	158.11	171.48
Recreation Boats	258.05	259.99	262.30	264.42	266.48	274.55	284.85	294.90	305.95	317.40
Lubricants	273.10	275.02	278.17	282.92	286.96	297.68	313.67	325.91	343.50	362.03
Pipeline Fuel Natural Gas	745.82	751.92	754.40	767.84	788.86	866.37	948.13	987.94	1051.32	1118.77

Table 34. Transportation Sector Energy Use by Fuel Type Within a Mode
(Trillion Btu per Year)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Total Miscellaneous	2061.64	2070.69	2079.57	2105.45	2140.18	2261.61	2385.11	2463.47	2572.59	2686.54
Total Consumption	27942.95	28472.98	29097.76	29683.93	30283.06	32438.40	34929.74	37136.76	40362.87	43869.23

1/ Commercial trucks from 8,500 to 10,000 pounds.
2/ Does not include military distillate. Does not include commercial buses.
3/ Does not include passenger rail.
Btu = British thermal unit.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 compressed natural gas volumes: Energy Information Administration (EIA), AEO2000 National Energy Modeling System run AEO2K.D10019KA. Other 1998 values derived using: EIA, Short-Term Energy Outlook, September 1999, Online. http:/www.eia.doe.gov/pub/forecasting/steo/oldsteos/sep99.html (October 12, 1999); EIA, Fuel Oil and Kerosene Sales 1997, DOE/EIA-0535(97) (Washington, D.C., August 1998); EIA, State Energy Data Report 1996, DOE/EIA-0214(96) (Washington, DC, Febuary 1999); Oak Ridge National Laboratory, Transportation Energy Book: 17 and 18 (September 1998); Department of Defense, Defense Fuel Supply Center; and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 35. Light-Duty Vehicle Energy Consumption by Technology Type and Fuel Type (Trillion Btu)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Light-Duty Consumption by Technology Type										
Conventional Vehicles 1/										
Gasoline ICE Vehicles	15539.39	15742.56	16035.33	16291.53	16568.42	17579.31	18673.73	19697.96	21171.39	22755.04
TDI Diesel ICE	160.20	150.93	145.78	145.12	139.70	153.39	234.17	323.81	354.58	388.27
Alternative-Fuel Vehicles										
Alcohol Fuel Technology										
Methanol-Flex Fuel ICE	101.97	131.00	158.99	185.93	212.14	292.21	335.99	339.76	676.76	1348.05
Methanol ICE	0.26	0.42	0.66	1.03	1.60	7.85	26.32	45.80	252.18	1388.51
Ethanol-Flex Fuel ICE	63.42	80.47	99.20	118.12	137.07	200.24	234.81	231.46	468.34	947.65
Ethanol Ice	0.12	0.20	0.32	0.52	0.81	3.65	11.28	18.03	96.20	513.29
Total Alcohol	165.77	212.09	259.18	305.60	351.61	503.94	608.40	635.05	1303.47	2675.44
Natural Gas Technology										
CNG ICE	91.82	111.11	129.33	145.26	158.41	200.34	242.75	271.53	495.66	904.79
CNG Bi-fuel	5.05	6.31	7.61	8.82	9.93	13.01	13.70	11.92	21.29	38.02
LPG ICE	48.66	54.77	60.61	65.73	70.01	83.96	98.21	107.43	150.69	211.38
LPG Bi-fuel	3.31	4.06	4.84	5.56	6.21	7.81	7.59	5.97	9.84	16.23
Total Natural Gas Technology	148.84	176.26	202.40	225.37	244.55	305.13	362.24	396.85	650.71	1066.95
Electric Technology										
Electric Vehicle	1.77	7.97	13.91	19.35	24.18	41.13	60.19	72.04	228.90	727.24
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.02
Total Electricity	1.77	7.97	13.91	19.35	24.18	41.14	60.21	72.07	228.99	727.59
Fuel Cell Technology										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fuel Cell	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Consumption by Fuel Type 1/										
Motor Gasoline	15646.60	15877.02	16203.42	16488.80	16793.74	17890.77	19016.85	20013.15	21578.62	23266.55
Distillate (diesel)	160.20	150.93	145.78	145.12	139.70	153.39	234.17	323.81	354.58	388.27
Methanol	40.09	50.67	55.12	63.29	72.07	100.96	131.99	151.95	296.26	577.62
Ethanol	17.44	21.98	27.15	32.42	37.73	57.10	73.67	79.38	169.05	360.00
Compressed Natural Gas	94.36	114.28	133.15	149.69	163.39	206.87	249.62	277.50	506.31	923.76
Liquid Petroleum Gas	49.69	56.03	62.13	67.49	71.98	86.44	100.63	109.31	153.63	215.93
Electricity	1.77	7.97	13.91	19.35	24.18	41.13	60.19	72.04	228.90	727.24
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1/ Includes personal vehicles and fleet vehicles. Includes both cars and trucks.
TDI = Turbo Direct Injection.
Btu = British thermal unit.
CNG = Compressed natural gas.
LPG = Liquid petroleum gas.
ICE = Internal combustion engine.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 45. Light-Duty Vehicle Sales by Technology Type (Thousands)
United States Total

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
New Car Sales 1/										
Conventional Vehicles										
Gasoline ICE Vehicles	6388.2	6328.8	6436.0	6487.0	6433.9	6332.1	6597.4	6572.3	6397.23	6226.79
TDI Diesel ICE	16.7	25.4	42.3	67.8	54.7	180.3	279.5	294.7	842.12	2405.99
Total Conventional	6404.9	6354.2	6478.3	6554.8	6488.6	6512.4	6876.9	6867.1	6750.50	6635.89
Alternative-Fuel Vehicles										
Methanol-Flex Fuel ICE	272.1	289.9	277.5	274.9	267.3	202.2	169.6	181.6	187.20	192.94
Methanol ICE	15.9	17.0	18.3	20.4	23.2	51.8	83.3	81.2	152.94	288.10
Ethanol-Flex Fuel ICE	170.5	176.4	184.1	184.8	178.4	147.5	113.6	98.0	96.92	95.88
Ethanol Ice	2.4	2.8	3.4	4.5	5.8	15.7	28.2	21.6	48.30	107.92
Electric Vehicle	2.2	101.3	103.7	105.5	105.0	106.2	113.0	113.1	324.66	932.25
Electric-Diesel Hybrid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	1.12
CNG ICE	79.2	81.3	84.2	87.1	88.0	92.5	99.5	97.5	125.43	161.37
CNG Bi-fuel	18.2	19.0	19.1	18.5	17.1	12.5	9.6	7.0	6.15	5.44
LPG ICE	33.0	34.3	36.1	38.1	39.3	42.2	43.9	40.9	49.89	60.92
LPG Bi-fuel	11.4	11.4	11.5	11.1	10.2	6.3	4.1	2.6	2.02	1.57
Fuel Cell Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Alternatives	605.0	733.3	737.9	745.0	734.3	676.9	664.6	643.4	744.98	862.59
Percent Alternative Car Sales	8.63	10.35	10.23	10.21	10.17	9.42	8.81	8.57	9.99	11.64
Total New Car Sales	7009.9	7087.5	7216.1	7299.7	7222.8	7189.3	7541.5	7510.5	7458.84	7407.54
New Light-Truck Sales 2/										
Conventional Vehicles										
Gasoline ICE Vehicles	5987.0	6146.3	6341.2	6476.6	6567.6	6739.6	7225.5	7315.3	7612.74	7922.25
TDI Diesel ICE	23.1	37.8	64.8	105.8	30.6	110.3	158.0	153.9	371.62	897.43
Total Conventional	6010.1	6184.1	6405.9	6582.4	6598.2	6849.9	7383.5	7469.2	7808.82	8163.88
Alternative-Fuel Vehicles										
Methanol-Flex Fuel ICE	99.5	116.8	108.8	108.9	110.2	88.9	79.4	55.5	58.82	62.37
Methanol Ice	21.1	21.9	22.7	23.6	24.0	27.0	30.1	28.6	41.34	59.74
Ethanol-Flex Fuel ICE	58.6	64.3	69.6	71.0	70.0	52.8	37.2	22.1	21.42	20.73
Ethanol ICE	2.9	3.0	3.2	3.5	3.7	5.0	5.9	4.9	7.60	11.68
Electric Vehicle	0.9	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.33	1.68
Electric-Diesel Hybrid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.21	5.31
CNG ICE	68.2	70.4	72.8	74.7	74.9	77.2	82.7	83.1	114.00	156.42
CNG Bi-fuel	0.3	0.3	0.3	0.3	0.2	0.1	0.0	0.0	0.01	0.00
LPG ICE	25.1	25.9	26.8	27.5	27.6	28.4	30.4	30.5	38.41	48.32
LPG Bi-fuel	0.3	0.3	0.3	0.2	0.2	0.1	0.0	0.0	0.00	0.00
Fuel Cell Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Alternatives	276.8	303.8	305.4	310.6	311.7	280.6	266.9	225.9	267.42	316.61
Percent Alternative Light Truck Sales	4.40	4.68	4.55	4.51	4.51	3.94	3.49	2.94	3.31	3.74
Total New Truck Sales	6286.9	6487.9	6711.3	6893.0	6909.9	7130.5	7650.4	7695.1	8067.75	8458.49
Percnt Total Alternative Sales	6.63	7.64	7.49	7.44	7.40	6.69	6.13	5.72	6.53	7.46
EPACT Legislative Alternative Sales	232.94	237.79	243.69	248.31	247.28	250.68	266.05	266.28	348.75	456.75
ZEVP Legislative Alternative Sales	0.00	247.62	253.49	258.05	256.78	259.74	275.30	275.38		
Total Vehicles Sales	13296.8	13575.4	13927.4	14192.7	14132.7	14319.8	15191.9	15205.6	15495.88	15791.74

1/ Includes personal and fleet light-duty cars.
2/ Includes personal and fleet light-duty trucks.
TDI = Turbo Direct Injection.
CNG = Compressed natural gas.
LPG = Liquid petroleum gas.
ICE = Internal combustion engine.
EPACT = Energy Policy Act of 1992.
ZEVP = Zero emission vehicles from the low emission vehicle program.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most

Table 45. Light-Duty Vehicle Sales by Technology Type (Thousands)
United States Total

available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1998 derived using: California Air Resources Board (CARB), "Proposed Regulations for Low-Emission Vehicles and Clean Fuels, Staff Report"; CARB, "Proposed Amendments to California Exhaust and Evaporative Emission Standards and Test Procedures for Passenger, Light-Duty Trucks and Medium-Duty Vehicle - LEVII and Proposed Amendments to California Motor Vehicle Certification: Assembly-Line and In-Use Test Requirements - CAP 2000," (El Monte, CA, September 1998);US Department of Energy, Argonne National Labortory, National Alternative-Fuel Survey, Model Version 28, July 21, 1998; Energy Information Administration (EIA), Describing Current and Potential Markets Alternative-Fuel Vehicles, DOE/EIA-0604(96) (Washington, DC, March 1996); EIA, Alternatives to Traditional Transportation Fuels 1996, DOE/EIA-0585(96) (Washington, DC, December 1997); and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.
Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 46. Light-Duty Vehicle Stock by Technology Type (Millions)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Light-Duty Car Stock 1/										
Conventional Vehicles										
Gasoline ICE Vehicles	112.33	109.84	107.58	105.51	103.55	96.88	92.36	91.06	85.43	80.14
TDI Diesel ICE	0.51	0.44	0.41	0.41	0.41	0.80	1.87	2.95	3.65	4.52
Total Conventional	112.84	110.28	107.99	105.92	103.96	97.68	94.23	94.01	88.64	83.58
Alternative-Fuel Vehicles										
Alcohol Fuel Technology										
Methanol-Flex Fuel ICE	1.14	1.42	1.69	1.95	2.19	2.84	3.04	2.95	5.47	10.15
Methanol ICE	0.00	0.01	0.01	0.02	0.02	0.11	0.38	0.66	3.58	19.39
Ethanol-Flex Fuel ICE	0.72	0.89	1.07	1.25	1.42	1.93	2.12	1.98	3.72	6.97
Ethanol Ice	0.00	0.00	0.00	0.01	0.01	0.05	0.15	0.24	1.27	6.69
Natural Gas Technology										
CNG ICE	0.34	0.42	0.49	0.57	0.65	0.93	1.18	1.31	2.53	4.88
CNG Bi-fuel	0.08	0.09	0.11	0.13	0.14	0.18	0.19	0.16	0.28	0.48
LPG ICE	0.17	0.20	0.23	0.27	0.30	0.41	0.52	0.57	0.92	1.48
LPG Bi-fuel	0.05	0.06	0.07	0.08	0.09	0.11	0.10	0.08	0.13	0.20
Electric Technology										
Electric Vehicle	0.01	0.11	0.21	0.32	0.42	0.81	1.22	1.47	5.90	23.67
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Technology										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Alternatives	2.51	3.21	3.90	4.59	5.24	7.38	8.91	9.42	18.44	36.10
Total Car Stock	115.35	113.49	111.89	110.51	109.20	105.07	103.15	103.44	99.58	95.86
Light-Duty Truck Stock 1/										
Conventional Vehicles										
Gasoline ICE Vehicles	76.45	79.40	82.39	85.37	88.27	98.43	109.04	117.70	135.41	155.78
TDI Diesel ICE	1.69	1.60	1.55	1.54	1.46	1.41	1.75	2.14	2.12	2.11
Total Conventional	78.14	81.00	83.94	86.91	89.74	99.84	110.79	119.84	137.37	157.46
Alternative-Fuel Vehicles										
Alcohol Fuel Technology										
Methanol-Flex Fuel ICE	0.43	0.56	0.68	0.80	0.91	1.24	1.48	1.52	3.03	6.07
Methanol ICE	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.22	0.98
Ethanol-Flex Fuel ICE	0.23	0.30	0.37	0.45	0.53	0.80	0.96	0.97	2.01	4.16
Ethanol Ice	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.12	0.53
Natural Gas Technology										
CNG ICE	0.28	0.35	0.41	0.48	0.55	0.80	1.06	1.24	2.43	4.74
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG ICE	0.21	0.23	0.24	0.26	0.28	0.35	0.42	0.47	0.60	0.76
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric Technology										
Electric Vehicle	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02		
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Technology										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Alternatives	1.16	1.44	1.73	2.01	2.29	3.22	3.99	4.30	7.64	13.60
Total Truck Stock	79.30	82.44	85.66	88.92	92.03	103.06	114.78	124.13	143.27	165.35
Total Vehicle Stock	194.65	195.93	197.56	199.43	201.23	208.13	217.92	227.57	237.57	248.01

1/ Includes personal and fleet vehicles.
TDI = Turbo Direct Injection.
ICE = Internal combustion engine.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Energy Information Administration (EIA), Household Vehicles Energy Consumption 1994, DOE/EIA-0464(94) (Washington, D.C., August 1997); EIA, Describing Current and Potential Markets for Alternative-Fuel Vehicles, DOE/EIA-0604(96) (Washington, DC, March 1996); EIA, Alternatives to Traditional Transportation Fuels 1996, DOE/EIA-0585(96) (Washington, DC, December 1997); Federal Highway Administration, Highway Statistics 1997, (Washington DC, November 1998); R.L. Polk and Company, Transportation Energy Data Book: Edition 18, "Automobiles in Operation and Vehicle Travel by Age in 1996" and "Trucking Operation and Vehicle Travel by Age in 1995", US Department of Energy, ORNL-6941, (Oak Ridge, TN., September 1998); and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 47. Light-Duty Vehicle MPG by Technology Type (MPG Gasoline Equivalents)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Automobiles 1/										
Conventional Vehicles										
Gasoline ICE Vehicles	29.00	29.77	29.75	29.84	30.05	30.94	31.17	31.09	31.82	32.56
TDI Diesel ICE	39.31	39.84	39.76	39.87	39.84	40.70	40.84	40.53	41.05	41.57
Alternative-Fuel Vehicles										
Alcohol Fuel Technology										
Methanol-Flex Fuel ICE	31.03	31.75	31.69	31.77	31.96	32.71	32.77	32.32	32.83	33.35
Methanol ICE	30.70	31.51	31.59	31.89	32.33	33.92	34.16	33.93	34.91	35.92
Ethanol-Flex Fuel ICE	30.74	31.47	31.41	31.49	31.67	32.26	32.41	32.19	32.76	33.33
Ethanol Ice	29.95	30.89	31.14	31.53	31.97	33.25	33.37	33.19	34.23	35.29
Natural Gas Technology										
CNG ICE	30.28	30.77	30.71	30.84	31.03	31.89	32.45	32.36	32.99	33.64
CNG Bi-fuel	27.90	28.47	28.41	28.54	28.73	29.57	29.96	29.95	30.60	31.26
LPG ICE	29.69	30.23	30.20	30.37	30.58	31.47	32.01	31.83	32.51	33.20
LPG Bi-fuel	28.27	28.84	28.77	28.88	29.04	29.82	30.41	30.31	30.95	31.61
Electric Technology										
Electric Vehicle	32.52	30.95	33.62	37.14	41.63	46.86	46.17	45.71	49.06	52.66
Electric-Diesel Hybrid	47.58	47.28	46.64	46.38	46.35	47.56	48.58	49.29	49.66	50.04
Fuel Cell Technology										
Fuel Cell Gasoline	0.00	0.00	0.00	42.82	42.56	41.69	40.67	39.63	38.61	37.63
Fuel Cell Methanol	0.00	0.00	0.00	45.65	45.36	44.31	43.13	42.07	40.93	39.83
Fuel Cell Hydrogen	0.00	0.00	0.00	49.89	49.53	48.35	47.33	46.47	45.38	44.32
Average New Car MPG	29.15	29.94	29.96	30.12	30.36	31.40	31.71	31.63	32.47	33.34
Light-Duty Trucks 1/										
Conventional Vehicles										
Gasoline ICE Vehicles	20.77	21.01	20.94	21.02	21.18	21.56	22.23	22.74	23.25	23.77
TDI Diesel ICE	26.71	26.96	26.84	26.93	28.52	29.02	29.68	29.98	30.79	31.62
Alternative-Fuel Vehicles										
Alcohol Fuel Technology										
Methanol-Flex Fuel ICE	21.36	21.66	21.66	21.70	21.83	22.18	22.70	23.02	23.56	24.12
Methanol ICE	20.21	20.50	20.48	20.64	20.92	21.64	22.52	23.06	23.94	24.85
Ethanol-Flex Fuel ICE	21.34	21.65	21.60	21.64	21.77	22.06	22.55	22.92	23.45	23.99
Ethanol Ice	19.53	19.86	19.89	20.11	20.47	21.55	22.42	22.74	23.72	24.75
Natural Gas Technology										
CNG ICE	20.19	20.46	20.42	20.55	20.79	21.23	21.90	22.56	23.29	24.05
CNG Bi-fuel	21.21	21.41	21.34	21.39	21.54	21.91	22.29	22.89	23.35	23.83
LPG ICE	19.52	19.80	19.75	19.87	20.11	20.57	21.23	21.88	22.59	23.32
LPG Bi-fuel	22.40	22.64	22.59	22.64	22.81	23.22	23.73	24.42	25.01	25.61
Electric Technology										
Electric Vehicle	22.98	25.15	27.32	30.11	33.68	37.48	36.25	35.42	38.85	42.62
Electric-Diesel Hybrid	35.57	35.78	35.53	35.53	35.78	36.45	36.97	37.36	38.06	38.77
Fuel Cell Technology										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	34.54	33.76	32.99	32.24
Fuel Cell Methanol	0.00	0.00	0.00	45.57	45.15	43.74	42.34	41.40	40.09	38.83
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average New Truck MPG	20.79	21.04	20.99	21.09	21.21	21.65	22.35	22.85	23.39	23.94
Fleet Average Stock Car MPG 2/	24.16	24.42	24.56	24.73	24.87	25.47	26.16	26.52	27.25	27.99
Fleet Average Stock Truck MPG 2/	16.81	16.89	16.89	16.92	16.92	17.00	17.15	17.37	17.50	17.62
Fleet Aver. Stock Vehicle MPG 2/	20.51	20.56	20.52	20.51	20.47	20.43	20.49	20.60	20.59	20.58

1/ Fuel efficiencies are EPA rated. Includes personal and fleet vehicles.
2/ Stock values are on road efficiencies. Includes personal vehicles, fleet vehicles, and freight light trucks.
TDI = Turbo Direct Injection.
CNG = Compressed natural gas.
LNG = Liquid natural gas.
MPG = Miles per Gallon.
ICE = Internal combustion engine.
N/A = Not applicable.
Note: The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Energy and Environmental Analysis Inc., Update to the Fuel Economy Model, prepared for Energy Information Administration (EIA) (Washington, DC, June 1998); National Highway Traffic and Safety Administration, Mid-Model Year Fuel Economy Reports from Auto Manufacturers, 1998; Federal Highway Administration, Highway Statistics 1997, (November 1998); United States Department of Commerce, Bureau of the Census, Truck Inventory and Use Survey, TC92-T-52 (Washington, DC, May 1995);and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 49. Light-Duty Vehicle VMT by Technology Type
(Billion Miles, Unless Otherwise Noted)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Conventional Vehicles 1/										
Gasoline ICE Vehicles	2543.6	2583.1	2625.0	2663.8	2703.5	2856.2	3032.2	3208.5	3443.29	3695.23
TDI Diesel ICE	27.2	25.7	25.0	25.2	24.6	30.1	51.1	73.6	85.23	98.68
Alternative-Fuel Vehicles										
Alcohol Fuel Technology										
Methanol-Flex Fuel ICE	21.0	27.0	32.7	38.1	43.1	58.3	66.3	67.1	132.17	260.21
Methanol ICE	0.1	0.1	0.1	0.2	0.3	1.7	5.9	10.2	57.43	322.19
Ethanol-Flex Fuel ICE	12.0	15.2	18.8	22.3	25.9	37.6	43.9	43.1	87.22	176.50
Ethanol Ice	0.0	0.0	0.1	0.1	0.2	0.8	2.4	3.9	21.05	114.58
Natural Gas Technology										
CNG ICE	14.9	18.2	21.2	23.9	26.2	33.8	41.8	47.1	87.39	162.15
CNG Bi-fuel	0.9	1.2	1.4	1.7	1.9	2.5	2.7	2.3	4.25	7.68
LPG ICE	7.7	8.8	9.8	10.7	11.5	14.2	17.0	18.8	27.18	39.23
LPG Bi-fuel	0.6	0.8	0.9	1.1	1.2	1.5	1.5	1.2	1.97	3.28
Electric Technology										
Electric Vehicle	0.4	1.7	3.0	4.4	5.8	11.4	17.7	21.7	75.18	260.55
Electric-Diesel Hybrid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Technology										
Fuel Cell Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VMT Equation Components										
Total VMT (billion miles)	2628.5	2681.9	2738.1	2791.5	2844.1	3048.3	3282.4	3497.6	3809.18	4148.47
VMT/Driving Population (thousand miles)	11.7	11.8	12.0	12.1	12.2	12.6	13.0	13.5	14.06	14.65
Driving Population (million)	217.0	219.2	221.4	223.7	226.0	235.2	245.6	255.3	267.27	279.82
Price Effects										
Motor Gasoline Price (1987 dollars/million Btu	7.49	7.52	7.56	7.62	7.62	7.63	7.63	7.60	7.93	8.27
Fleet Miles per Gallon	20.61	20.65	20.59	20.57	20.53	20.48	20.52	20.63	20.59	20.55
Real Cost of Driving per Mile (1987 cents)	4.546	4.553	4.591	4.630	4.643	4.663	4.650	4.604	4.81	5.03
Point Price Elasticity	-0.040	-0.040	-0.040	-0.040	-0.040	-0.039	-0.037	-0.035	-0.04	-0.04
Income Effects										
Disposable Income (billion 1987 dollars)	4932.6	5049.2	5190.5	5323.0	5453.2	5986.5	6716.6	7485.5	8426.97	9486.88
Point Income Elasticity	0.452	0.455	0.459	0.463	0.466	0.481	0.499	0.516	0.54	0.56
Demographic Driving Population Effect										
Percentage Female Driving Population	0.766	0.774	0.780	0.785	0.789	0.796	0.796	0.796	0.82	0.84
Point Demographic Elasticity	0.257	0.257	0.256	0.256	0.255	0.249	0.240	0.232	0.23	0.23

1/ Includes personal and fleet vehicles. Includes both cars and light trucks.
TDI = Turbo Direct Injection.
CNG = Compressed natural gas.
LNG = Liquid natural gas.
VMT = Vehicle miles traveled.
ICE = Internal combustion engine.
Btu = British thermal unit.
N/A = Not applicable.
Note: The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Federal Highway Administration, Highway Statistics 1996, (November 1997); Oak Ridge National Laboratory, Transportation Energy Data Book: 18,(September 1998); United States Department of Commerce, Bureau of the Census, Truck Inventory and Use Survey, TC92-T-52 (Washington, DC, May 1995); and Energy Information Administration (EIA), AEO2000 National Energy Modeling System run AEO2K.D100199A.
Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 50. Summary of New Light-Duty Vehicle Size Class Attributes

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Personal Vehicles										
New Fuel Efficiency EPA Rated										
Conventional Cars (MPG)										
Minicompact	26.997	27.745	27.749	28.024	28.364	29.371	29.687	29.806	30.72	31.66
Subcompact	32.624	33.261	33.255	33.302	33.461	34.073	33.985	33.658	34.09	34.53
Compact	31.605	32.497	32.464	32.526	32.719	33.543	33.622	33.389	34.04	34.71
Mid-size	27.925	28.537	28.521	28.633	28.855	29.743	29.995	29.969	30.66	31.36
Large	25.304	26.033	26.031	26.167	26.402	27.506	28.111	28.290	29.19	30.12
Two Seater	25.557	26.179	26.175	26.324	26.560	27.303	27.437	27.387	28.00	28.64
Average New Car	29.578	30.410	30.386	30.478	30.683	31.557	31.745	31.625	32.35	33.09
Average New Car On-Road MPG	25.246	26.026	25.974	26.053	26.195	26.806	26.767	26.500	26.94	27.38
Conventional Light Trucks										
Small Pickup	24.162	24.323	24.225	24.142	24.169	24.223	24.680	24.994	25.28	25.57
Large Pickup	18.482	18.597	18.505	18.575	18.740	19.131	19.882	20.473	20.95	21.43
Small Van	25.174	25.478	25.450	25.489	25.632	25.712	26.263	26.840	27.40	27.98
Large Van	19.188	19.512	19.492	19.660	19.942	20.603	21.502	22.259	23.24	24.27
Small Utility	21.760	22.056	22.006	22.032	22.183	22.559	23.196	23.567	24.17	24.80
Large Utility	14.791	14.989	14.998	15.127	15.337	15.886	16.511	16.980	16.94	16.90
Average New Light Truck	20.866	21.087	21.014	21.076	21.212	21.556	22.197	22.659	23.08	23.50
Average New LT On-Road MPG	16.841	17.065	16.985	17.034	17.122	17.330	17.683	17.932	18.15	18.36
Degradation Factors 1/										
Cars	0.854	0.856	0.855	0.855	0.854	0.849	0.843	0.838	0.83	0.83
Light Trucks	0.807	0.809	0.808	0.808	0.807	0.804	0.797	0.791	0.79	0.78
New Fuel Efficiency by										
Size Class 2/										
Alternative-Fuel Cars										
Minicompact	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact	36.874	37.540	37.479	37.510	37.672	38.506	38.614	38.214	38.71	39.22
Compact	30.725	31.551	31.482	31.533	31.718	32.576	32.689	32.384	32.97	33.56
Midsize	29.118	29.738	29.697	29.822	30.064	31.001	31.396	31.287	32.01	32.75
Large	27.224	27.976	27.989	28.152	28.418	29.710	30.747	30.953	32.05	33.19
2-Seater	30.195	30.872	33.434	36.774	40.999	45.906	45.658	45.251	50.08	55.41
Average New Alternative Cars	25.689	26.279	26.680	27.299	28.145	29.616	29.851	29.682	30.87	32.10
Alternative-Fuel Light Trucks										
Small Pickup	25.019	25.252	25.153	25.084	25.145	25.436	26.093	26.299	26.73	27.17
Large Pickup	18.237	18.354	18.257	18.333	18.508	18.986	19.857	20.461	21.04	21.63
Small Van	22.720	23.025	22.956	22.952	23.084	23.554	24.321	24.590	25.18	25.78
Large Van	18.455	18.770	18.749	18.920	19.205	19.936	20.947	21.712	22.75	23.83
Small Utility	21.229	21.528	21.455	21.467	21.601	22.015	22.670	22.976	23.55	24.15
Large Utility	16.568	16.791	16.791	16.936	17.171	17.778	18.478	18.999	19.75	20.54
Average New Alt. Light Trucks	20.371	20.620	20.560	20.615	20.786	21.284	22.061	22.506	23.16	23.83
Fleet Vehicles										
New Fuel Efficiency EPA Rated										
Cars	27.584	28.230	28.217	28.338	28.563	29.506	29.860	29.873	30.64	31.43
Light Trucks	20.513	20.785	20.742	20.844	21.058	21.527	22.289	22.901	23.63	24.39
Average On Road MPG										
Cars	23.286	23.641	23.834	24.050	24.222	24.807	25.234	25.091	25.69	26.30
Light Trucks	16.322	16.502	16.590	16.682	16.772	17.101	17.534	17.961	18.50	19.06
New Vehicle Sales Shares (percent)										
Conventional Cars										
Minicompact	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.00	0.00
Subcompact	0.167	0.165	0.163	0.162	0.161	0.156	0.151	0.146	0.14	0.14
Compact	0.389	0.389	0.391	0.393	0.393	0.394	0.394	0.394	0.40	0.41
Mid-Size	0.314	0.313	0.312	0.311	0.311	0.311	0.311	0.311	0.30	0.30
Large	0.119	0.120	0.121	0.122	0.123	0.127	0.133	0.137	0.14	0.14
Two Seater	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.01	0.01
Conventional Light Trucks										
Small Pickup	0.154	0.153	0.149	0.147	0.147	0.145	0.142	0.138	0.13	0.12
Large Pickup	0.200	0.198	0.194	0.193	0.192	0.188	0.184	0.178	0.17	0.17
Small Van	0.210	0.210	0.207	0.209	0.209	0.210	0.209	0.206	0.21	0.21

Table 50. Summary of New Light-Duty Vehicle Size Class Attributes

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Large Van	0.019	0.018	0.017	0.017	0.017	0.017	0.017	0.016	0.02	0.01
Small Utility	0.317	0.319	0.327	0.328	0.329	0.333	0.340	0.350	0.36	0.37
Large Utility	0.101	0.102	0.105	0.105	0.105	0.107	0.109	0.112	0.12	0.12
New Vehicle Average Horse Power										
Conventional Cars										
Minicompact	206.056	207.351	211.521	215.644	219.400	231.121	243.312	255.316	271.47	288.65
Subcompact	141.083	145.146	146.804	151.784	156.665	174.973	194.446	210.876	231.38	253.87
Compact	140.472	144.726	146.887	151.607	156.268	173.584	192.668	208.428	217.04	226.01
Mid-Size	176.824	180.355	183.453	188.465	193.349	211.404	230.111	245.959	259.78	274.38
Large	225.279	230.245	234.015	238.919	243.624	261.823	281.950	297.506	322.87	350.39
Two Seater	246.318	250.873	255.189	261.279	267.059	287.515	307.994	326.396	378.62	439.19
Average New Car	163.193	167.327	170.013	174.912	179.774	197.947	217.548	233.808	248.35	263.79
Conventional Light Trucks										
Small Pickup	157.396	163.849	165.631	174.437	183.413	206.671	230.727	249.470	270.33	292.93
Large Pickup	241.234	247.374	251.368	260.180	268.913	295.280	320.657	340.158	374.46	412.22
Small Van	184.347	190.285	194.075	203.460	212.986	238.774	268.210	290.847	314.93	341.01
Large Van	232.691	236.779	240.111	246.349	252.342	271.767	292.681	308.119	335.62	365.58
Small Utility	194.736	200.905	205.104	213.682	222.272	245.719	269.981	289.693	313.19	338.60
Large Utility	211.182	216.941	221.368	229.625	237.687	260.920	284.573	303.541	324.59	347.09
Average New Light Truck	198.484	204.532	208.260	216.986	225.715	249.993	275.324	295.230	320.40	347.72

1/ Conversion factor used to convert Environmental Protection Agency rated to "on road" miles per gallon.
2/ Environmental Protection Agency rated miles per gallon.
MPG = Milers per gallon.
EPA = Environmental Protection Agency.
N/A = Not applicable.

Note: The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1998 derived using: Energy and Environmental Analysis Inc., Updates to the Fuel Economy Model, prepared for Energy Information Administarion (EIA) (Washington, DC, June 1998); National Highway Traffic and Safety Administration, Mid-Year Fuel Economy Reports from Auto Manufacturers, 1998; Federal Highway Administration, Highway Statistics 1997, (November 1998); Oak Ridge National Laboratory, "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices," prepared for the U.S. Department of Energy, Office of Transportation Technologies, and Office of Policy (March 1992); and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO99 National Energy Modeling System run AEO2K.D100199A.

Table 51. Transportation Fleet Car and Truck Fuel Consumption by Type and Technology
(Trillion Btu)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Cars 1/										
Gasoline Conventional	930.99	879.17	861.28	854.13	852.49	825.40	833.85	849.12	800.63	754.92
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	1.61	1.91	2.13	2.24	2.24	2.19	2.19	2.25	3.49	5.43
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	0.19	0.22	0.25	0.27	0.27	0.26	0.26	0.27	0.42	0.65
CNG	37.89	44.68	49.45	51.86	52.27	51.39	51.04	52.33	81.08	125.62
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	15.98	18.29	19.94	20.78	20.95	20.57	20.45	20.96	28.51	38.77
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	1.06	1.24	1.33	1.34	1.29	0.96	0.94	0.98	1.37	1.93
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Cars	987.73	945.51	934.38	930.62	929.51	900.77	908.73	925.89	887.88	851.43
Light Trucks 1/										
Gasoline Conventional	1671.40	1648.07	1637.24	1653.30	1673.73	1718.31	1759.42	1771.87	1808.87	1846.65
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	3.69	4.52	5.29	5.91	6.26	6.45	6.56	6.62	11.10	18.60
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	0.51	0.63	0.74	0.83	0.88	0.90	0.92	0.93	1.56	2.63
CNG	49.16	59.28	68.43	75.47	79.44	81.87	83.91	85.14	140.70	232.53
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	19.97	22.99	25.70	27.84	29.06	29.88	30.60	30.98	43.25	60.37
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	0.58	0.66	0.70	0.71	0.68	0.54	0.57	0.61	0.85	1.20
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Light Trucks	1745.32	1736.15	1738.10	1764.05	1790.04	1837.95	1881.97	1896.15	1961.03	2028.14
Total Fleet Vehicles	2733.04	2681.66	2672.48	2694.67	2719.55	2738.72	2790.70	2822.04	2838.99	2856.04
Commercial Light Trucks 2/	642.33	652.28	662.80	673.12	681.61	714.04	757.35	793.22	841.13	891.93

1/ Includes all fleets of 10 or more.
2/ Commercial trucks from 8,500 to 10,000 pounds.
ICE = Internal combustion engine.
CNG = Compressed natural gas.
LPG = Liquid petroleum gas.
N/A = Not Applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Oak Ridge National Laboratory, "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices," prepared for the Department of Energy, Office of Transportation Technologies, and Office of Policy, Planning, and Analysis, March 1992; Bobit Publishing Company, Fleet Fact Book, Redondo Beach, California, various issues; United States Department of Commerce, Bureau of the Census, "Trucks Inventory and Use Survey," TC92-T-52, (Washington, DC, May 1995); Federal Highway Administration, Highway Statistics 1997 (November 1998); Decision Analysis Corporation of Virginia, NEMS Transportation Sector Model: Development of the Light Commercial Truck Model, Final Report, Subtask 19-2, prepared for the Energy Information Administration (EIA) (April 23, 1997); and EIA AEO2000 National Energy Modeling System run AEO2K.D100199A.
Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 52. Transportation Fleet Car and Truck Sales by Type and Technology (Thousands)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Cars 1/										
Gasoline Conventional	1612.82	1630.48	1657.07	1676.42	1659.29	1653.99	1737.18	1730.56	1697.47	1665.00
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	14.37	14.52	14.76	14.93	14.78	14.73	15.47	15.42	20.22	26.52
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	1.68	1.70	1.73	1.75	1.73	1.72	1.81	1.80	2.43	3.27
CNG	76.79	77.63	78.89	79.81	79.00	78.75	82.71	82.39	102.45	127.39
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	31.10	31.44	31.96	32.33	32.00	31.90	33.50	33.37	39.15	45.93
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	2.19	2.22	2.25	2.28	2.26	2.25	2.36	2.35	2.80	3.34
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Cars	1738.95	1757.99	1786.66	1807.52	1789.05	1783.34	1873.03	1865.90	1849.81	1833.85
Light Trucks 1/										
Gasoline Conventional	1713.55	1767.44	1827.18	1875.56	1879.46	1937.37	2076.96	2088.09	2160.08	2234.55
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	20.90	21.56	22.29	22.88	22.93	23.63	25.33	25.47	35.90	50.61
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	2.80	2.89	2.99	3.07	3.07	3.17	3.40	3.41	4.85	6.89
CNG	68.15	70.30	72.67	74.60	74.75	77.06	82.61	83.05	113.96	156.37
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	25.04	25.83	26.70	27.41	27.46	28.31	30.35	30.51	38.38	48.27
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	0.87	0.89	0.92	0.95	0.95	0.98	1.05	1.06	1.33	1.68
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Light Trucks	1831.31	1888.90	1952.75	2004.45	2008.62	2070.52	2219.69	2231.59	2332.41	2437.79
Total Fleet Vehicles	3570.26	3646.90	3739.41	3811.97	3797.67	3853.86	4092.73	4097.49	4174.37	4252.71
Commercial Light Trucks 2/	918.94	949.50	983.30	1010.75	1013.89	1049.26	1128.76	1135.92	1191.81	1250.44

1/ Includes all fleets of 10 or more.
2/ Commercial trucks from 8,500 to 10,000 pounds.
ICE = Internal combustion engine.
CNG = Compressed natural gas.
LNG = Liquid petroleum gas.
N/A = Not Applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Oak Ridge National Laboratory, "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices," prepared for the Department of Energy, Office of Transportation Technologies, and Office of Policy, Planning, and Analysis, March 1992; Bobit Publishing Company, Fleet Fact Book, Redondo Beach, California, various issues; United States Department of Commerce, Bureau of the Census, "Truck Inventory and Use Survey," TC92-T-52, (Washington, DC, May 1995); Federal Highway Administration, Highway Statistics 1997 (November 1998); Decision Analysis Corporation of Virginia, NEMS Tramsportation Sector Model:Development of the Light Commercial Truck Model, Final Report, Subtask 19-2, prepared for the Energy Information Administration (EIA) (April 23, 1997); Energy Information Administration (EIA), Describing Current and Potential Markets for Alternative-Fuel Vehicles, DOE/EIA-0604(96) (Washington, DC, March 1996); EIA, Alternatives to Traditional Transportation Fuels 1996, DOE/EIA-0585(96) (Washington, DC, December 1997); and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 53. Transportation Fleet Car and Truck Stock by Type and Technology (Thousands)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Cars 1/										
Gasoline Conventional	6878.93	6587.59	6494.21	6491.26	6525.95	6481.36	6657.72	6745.01	6507.56	6278.47
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	51.86	62.16	69.76	73.92	74.33	74.35	75.76	77.28	122.63	194.60
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	5.85	7.03	7.93	8.43	8.45	8.45	8.62	8.79	14.08	22.55
CNG	303.72	361.69	401.48	422.87	427.97	428.85	435.98	445.65	702.69	1107.99
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	125.31	144.96	158.59	166.02	168.11	168.33	171.27	174.95	242.63	336.48
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	9.34	11.04	12.14	12.72	12.93	12.98	13.17	13.48	20.84	32.20
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Cars	7375.01	7174.46	7144.10	7175.22	7217.75	7174.32	7362.52	7465.17	7346.21	7229.15
Light Trucks 1/										
Gasoline Conventional	8706.63	8678.26	8652.93	8772.73	8924.61	9353.36	9821.04	10141.10	10672.11	11230.92
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	74.12	91.75	107.93	121.00	128.91	136.17	142.60	148.10	255.23	439.87
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	9.88	12.27	14.49	16.29	17.38	18.36	19.23	19.97	34.69	60.27
CNG	247.24	301.31	348.93	386.54	408.96	431.44	451.99	468.99	794.16	1344.79
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	97.11	113.00	126.75	137.92	144.70	152.40	159.75	165.55	236.67	338.34
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	3.41	3.93	4.31	4.57	4.71	4.94	5.18	5.36	8.26	12.72
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Light Trucks	9138.39	9200.52	9255.34	9439.04	9629.26	10096.66	10599.79	10949.07	11693.34	12488.20
Total Fleet Vehicles	16513.40	16374.98	16399.44	16614.26	16847.02	17270.98	17962.30	18414.24	18955.65	19512.99
Commercial Light Trucks 2/	10796.77	11016.25	11254.67	11504.41	11740.42	12596.80	13617.14	14488.95	15805.73	17242.18

1/ Includes all fleets of 10 or more.
2/ Commercial trucks from 8,500 to 10,000 pounds.
CNG = Compressed natural gas.
LNG = Liquid petroleum gas.
ICE = Internal combustion engine.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Oak Ridge National Laboratory, "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices," prepared for the Department of Energy, Office of Transportation Technologies, and Office of Policy, Planning, and Analysis, March 1992; Bobit Publishing Company, Fleet Fact Book, Redondo Beach, California, various issues; United States Department of Commerce, Bureau of the Census, "Truck Inventory and Use Survey," TC92-T-52, (Washington, DC, May 1995); Federal Highway Administration, Highway Statistics 1997, (Novemeber 1998); Decision Analysis Corporation of Virginia, NEMS Transportation Sector Model: Development of the Light Comercial Truck Model, Final Report, Subtask 19-2, (April 23, 1997); Energy Information Administration (EIA), Describing Current and Potential Markets for Alternative-Fuel Vehicles, DOE/EIA-0604(96) (Washington, DC, March 1996); EIA, Alternatives to Traditional Transportation Fuels 1996, DOE/EIA-0585(96) (Washington, DC, December 1997); and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 54. Transportation Fleet Car and Truck VMT by Type and Technology
(Billion Miles)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Cars 1/										
Gasoline Conventional	176.22	168.54	166.20	166.21	167.10	165.70	170.22	172.31	165.97	159.87
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	1.33	1.59	1.79	1.89	1.90	1.90	1.94	1.97	3.13	4.96
Ethanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	0.15	0.18	0.20	0.22	0.22	0.22	0.22	0.22	0.36	0.57
CNG	7.78	9.25	10.27	10.83	10.96	10.96	11.15	11.38	17.92	28.21
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	3.21	3.71	4.06	4.25	4.30	4.30	4.38	4.47	6.19	8.57
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	0.24	0.28	0.31	0.33	0.33	0.33	0.34	0.34	0.53	0.82
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Cars	188.93	183.56	182.83	183.73	184.82	183.42	188.24	190.70	187.36	184.08
Light Trucks 1/										
Gasoline Conventional	223.05	222.03	221.44	224.63	228.52	239.13	251.09	259.06	272.18	285.97
Distillate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol										
Flex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neat	1.90	2.35	2.76	3.10	3.30	3.48	3.65	3.78	6.51	11.20
Ethanol										
Flex	0.25	0.31	0.37	0.42	0.44	0.47	0.49	0.51	0.88	1.53
Neat	0.25	0.31	0.37	0.42	0.44	0.47	0.49	0.51	0.88	1.53
CNG	6.33	7.71	8.93	9.90	10.47	11.03	11.56	11.98	20.25	34.24
CNG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	2.49	2.89	3.24	3.53	3.71	3.90	4.08	4.23	6.04	8.62
LPG Bi-fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	0.09	0.10	0.11	0.12	0.12	0.13	0.13	0.14	0.21	0.32
Electric-Diesel Hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell										
Fuel Cell Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Fleet Light Truck	234.36	235.71	237.23	242.11	247.01	258.60	271.49	280.21	298.88	318.80
Total Fleet Vehicles	423.29	419.26	420.06	425.84	431.83	442.02	459.73	470.91	484.08	497.62
Commercial Light Trucks 2/	77.89	79.61	81.38	83.12	84.64	90.46	98.16	104.93	114.22	124.33

1/ Includes all fleets of 10 or more.
2/ Commercial trucks from 8,500 to 10,000 pounds.
CNG = Compressed natural gas.
LNG = Liquid petroleum gas.
ICE = Internal combustion engine.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Sources: 1998 derived using: Oak Ridge National Laboratory, "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices," prepared for the Department of Energy, Office of Transportation Technologies, and Office of Policy, Planning, and Analysis, March 1992; Bobit Publishing Company, Fleet Fact Book, Redondo Beach, California, various issues; Federal Highway Administration, Highway Statistics 1997, (Novemeber 1998); Decision Analysis Corporation of Virginia, NEMS Transportation Sector Model: Development of the Light Comercial Truck Model, Final Report, Subtask 19-2, (April 23, 1997); and Energy Information Administration (EIA), AEO2000 National Energy Modeling System run AEO2K.D100199A. Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 57. New Light-Duty Vehicle Fuel Economy
(Miles per Gallon)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Gasoline										
Minincompact Cars	27.00	27.75	27.75	28.02	28.36	29.37	29.69	29.81	30.72	31.66
Subcompact Cars	32.62	33.26	33.25	33.30	33.46	34.07	33.99	33.66	34.09	34.53
Compact Cars	31.61	32.50	32.46	32.53	32.72	33.54	33.62	33.39	34.04	34.71
Midsize Cars	27.92	28.54	28.52	28.63	28.85	29.74	29.99	29.97	30.66	31.36
Large Cars	25.30	26.03	26.03	26.17	26.40	27.51	28.11	28.29	29.19	30.12
2-Seater Cars	25.56	26.18	26.17	26.32	26.56	27.30	27.44	27.39	28.00	28.64
Small Pickup	24.16	24.32	24.22	24.14	24.17	24.22	24.68	24.99	25.28	25.57
Large Pickup	18.48	18.60	18.51	18.57	18.74	19.13	19.88	20.47	20.95	21.43
Small Van	25.17	25.48	25.45	25.49	25.63	25.71	26.26	26.84	27.40	27.98
Large Van	19.19	19.51	19.49	19.66	19.94	20.60	21.50	22.26	23.24	24.27
Small Utility	21.76	22.06	22.01	22.03	22.18	22.56	23.20	23.57	24.17	24.80
Large Utility	14.79	14.99	15.00	15.13	15.34	15.89	16.51	16.98	16.94	16.90
Turbo Direct Injection Diesel										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	40.67	41.20	41.11	41.17	41.34	42.05	41.94	41.44	41.81	42.19
Midsize Cars	38.56	39.01	38.92	39.06	39.30	40.25	40.42	40.16	40.75	41.36
Large Cars	36.05	36.85	36.83	37.00	37.26	38.48	39.28	39.50	40.51	41.53
2-Seater Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Pickup	33.23	33.48	33.36	33.28	33.34	33.40	33.72	33.83	34.13	34.43
Large Pickup	24.18	24.28	24.16	24.26	24.47	24.79	25.65	26.32	26.87	27.44
Small Van	30.13	30.47	30.38	30.37	30.52	30.76	31.28	31.50	31.99	32.49
Large Van	24.43	24.80	24.79	25.01	25.35	25.96	26.93	27.77	28.85	29.98
Small Utility	28.13	28.48	28.39	28.41	28.58	28.92	29.52	29.83	30.43	31.05
Large Utility	21.92	22.19	22.18	22.38	22.68	23.21	24.00	24.60	25.44	26.31
Methanol										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	39.15	39.74	39.68	39.71	39.85	40.52	40.39	39.94	40.31	40.67
Compact Cars	32.63	33.42	33.34	33.38	33.55	34.22	34.17	33.85	34.32	34.80
Midsize Cars	30.95	31.56	31.52	31.63	31.87	32.72	32.86	32.74	33.37	34.01
Large Cars	28.95	29.77	29.77	29.91	30.15	31.33	32.01	32.17	33.12	34.09
2-Seater Cars	32.13	33.05	33.15	33.53	33.99	35.47	36.18	36.53	37.94	39.40
Small Pickup	26.60	26.84	26.74	26.66	26.71	26.87	27.32	27.49	27.83	28.17
Large Pickup	19.38	19.49	19.39	19.47	19.64	20.01	20.78	21.38	21.89	22.42
Small Van	24.14	24.45	24.37	24.36	24.48	24.80	25.38	25.62	26.11	26.61
Large Van	19.60	19.92	19.90	20.07	20.36	20.96	21.86	22.61	23.58	24.58
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methanol Flex										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	37.00	37.66	37.59	37.61	37.76	38.42	38.30	37.89	38.28	38.68
Compact Cars	30.85	31.67	31.60	31.64	31.81	32.47	32.43	32.12	32.60	33.09
Midsize Cars	29.26	29.89	29.84	29.96	30.18	31.01	31.17	31.08	31.71	32.36
Large Cars	27.41	28.18	28.19	28.31	28.55	29.70	30.35	30.52	31.45	32.41
2-Seater Cars	30.37	31.31	31.40	31.76	32.21	33.62	34.33	34.66	36.04	37.46
Small Pickup	25.13	25.35	25.25	25.18	25.23	25.42	25.89	26.06	26.40	26.75
Large Pickup	18.31	18.42	18.32	18.39	18.56	18.94	19.68	20.26	20.76	21.28
Small Van	22.81	23.11	23.03	23.02	23.14	23.47	24.07	24.30	24.79	25.29
Large Van	18.52	18.83	18.81	18.97	19.25	19.87	20.73	21.46	22.40	23.38
Small Utility	21.30	21.60	21.53	21.54	21.68	22.08	22.73	23.03	23.60	24.19
Large Utility	16.62	16.84	16.84	16.99	17.23	17.83	18.53	19.05	19.80	20.59
Ethanol										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	37.73	38.36	38.30	38.32	38.46	39.12	39.01	38.59	38.97	39.36
Compact Cars	31.44	32.26	32.19	32.22	32.39	33.06	33.02	32.70	33.18	33.67
Midsize Cars	29.83	30.45	30.41	30.52	30.75	31.58	31.74	31.64	32.27	32.91
Large Cars	27.93	28.71	28.72	28.85	29.08	30.25	30.90	31.08	32.01	32.97
2-Seater Cars	30.96	31.89	31.98	32.35	32.80	34.23	34.95	35.29	36.67	38.11
Small Pickup	25.62	25.85	25.75	25.68	25.73	25.91	26.37	26.54	26.88	27.23
Large Pickup	18.67	18.78	18.68	18.75	18.92	19.30	20.05	20.63	21.14	21.66

Table 57. New Light-Duty Vehicle Fuel Economy
(Miles per Gallon)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Small Van	23.25	23.56	23.48	23.47	23.59	23.91	24.51	24.74	25.23	25.74
Large Van	18.88	19.20	19.18	19.34	19.62	20.23	21.11	21.84	22.79	23.78
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ethanol Flex										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	36.65	37.31	37.25	37.27	37.41	38.07	37.96	37.55	37.95	38.34
Compact Cars	30.55	31.38	31.31	31.35	31.52	32.18	32.14	31.83	32.32	32.81
Midsize Cars	28.98	29.61	29.57	29.68	29.90	30.73	30.89	30.80	31.43	32.08
Large Cars	27.15	27.92	27.92	28.05	28.28	29.43	30.07	30.25	31.17	32.13
2-Seater Cars	30.08	31.02	31.11	31.47	31.91	33.31	34.03	34.35	35.72	37.14
Small Pickup	24.88	25.11	25.01	24.94	24.99	25.18	25.65	25.82	26.16	26.51
Large Pickup	18.13	18.24	18.15	18.22	18.38	18.76	19.50	20.07	20.57	21.09
Small Van	22.59	22.88	22.81	22.80	22.91	23.25	23.85	24.08	24.57	25.08
Large Van	18.34	18.65	18.63	18.79	19.06	19.69	20.54	21.26	22.20	23.18
Small Utility	21.09	21.39	21.32	21.34	21.47	21.88	22.52	22.82	23.40	23.98
Large Utility	16.46	16.68	16.68	16.83	17.06	17.67	18.36	18.88	19.63	20.41
Compressed Natural Gas (CNG)										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	32.28	32.86	32.75	32.82	32.94	33.61	33.83	33.45	33.87	34.28
Midsize Cars	30.69	31.10	31.02	31.15	31.33	32.18	32.62	32.46	33.04	33.63
Large Cars	28.81	29.47	29.45	29.59	29.78	30.73	31.86	31.97	32.88	33.81
2-Seater Cars	32.07	32.97	33.06	33.45	33.91	35.37	36.08	36.42	37.81	39.25
Small Pickup	26.46	26.68	26.55	26.47	26.52	26.53	26.75	27.10	27.37	27.64
Large Pickup	19.35	19.45	19.34	19.42	19.58	19.89	20.50	21.09	21.54	22.00
Small Van	24.06	24.36	24.27	24.25	24.37	24.56	24.94	25.33	25.76	26.19
Large Van	19.57	19.89	19.86	20.03	20.32	20.85	21.58	22.32	23.21	24.13
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CNG Bi-Fuel										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	29.94	30.56	30.46	30.51	30.64	31.28	31.51	31.17	31.60	32.04
Midsize Cars	28.47	28.90	28.84	28.96	29.14	29.94	30.38	30.25	30.83	31.43
Large Cars	26.78	27.38	27.36	27.49	27.68	28.61	29.64	29.77	30.65	31.56
2-Seater Cars	29.73	30.64	30.73	31.08	31.52	32.89	33.60	33.92	35.26	36.65
Small Pickup	24.52	24.73	24.61	24.54	24.58	24.63	24.89	25.23	25.50	25.78
Large Pickup	17.93	18.03	17.93	18.00	18.15	18.47	19.06	19.63	20.06	20.50
Small Van	22.31	22.59	22.51	22.49	22.60	22.81	23.22	23.59	24.02	24.46
Large Van	18.15	18.44	18.42	18.57	18.84	19.40	20.10	20.80	21.66	22.55
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquefied Petroleum Gas (LPG)										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	37.33	37.77	37.68	37.73	37.83	38.48	38.69	38.21	38.54	38.88
Compact Cars	31.20	31.83	31.73	31.79	31.91	32.60	32.85	32.49	32.93	33.39
Midsize Cars	29.62	30.06	29.99	30.12	30.30	31.15	31.61	31.47	32.08	32.69
Large Cars	27.81	28.47	28.45	28.58	28.78	29.73	30.83	30.96	31.88	32.82
2-Seater Cars	30.94	31.87	31.96	32.33	32.78	34.21	34.92	35.26	36.63	38.06
Small Pickup	25.51	25.74	25.63	25.55	25.61	25.66	25.92	26.28	26.58	26.88
Large Pickup	18.64	18.75	18.65	18.72	18.89	19.22	19.83	20.42	20.88	21.35
Small Van	23.20	23.50	23.42	23.41	23.53	23.75	24.16	24.55	25.00	25.46
Large Van	18.87	19.18	19.15	19.32	19.60	20.16	20.89	21.62	22.51	23.44
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG Bi-Fuel										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	30.03	30.69	30.59	30.65	30.77	31.45	31.71	31.35	31.81	32.27

Table 57. New Light-Duty Vehicle Fuel Economy
(Miles per Gallon)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Midsize Cars	28.52	28.99	28.92	29.05	29.23	30.06	30.51	30.39	31.00	31.62
Large Cars	26.80	27.44	27.41	27.54	27.74	28.68	29.74	29.88	30.78	31.71
2-Seater Cars	29.78	30.71	30.80	31.15	31.59	32.97	33.69	34.02	35.37	36.78
Small Pickup	24.56	24.79	24.68	24.61	24.66	24.74	25.01	25.37	25.68	25.99
Large Pickup	17.94	18.05	17.95	18.02	18.18	18.51	19.12	19.70	20.15	20.62
Small Van	22.33	22.63	22.55	22.54	22.65	22.89	23.31	23.70	24.15	24.62
Large Van	18.16	18.46	18.44	18.60	18.86	19.44	20.15	20.87	21.75	22.66
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	34.87	37.92	41.17	45.50	51.02	57.38	56.44	55.75	61.57	68.00
Compact Cars	30.47	33.09	35.98	39.78	44.63	50.44	49.84	49.34	54.72	60.68
Midsize Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Seater Cars	28.43	30.86	33.53	37.03	41.51	46.73	46.05	45.59	50.40	55.73
Small Pickup	26.65	28.99	31.45	34.64	38.71	43.01	41.63	40.70	44.45	48.54
Large Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Van	22.98	25.15	27.32	30.11	33.68	37.48	36.25	35.42	38.85	42.62
Large Van	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diesel-Electric Hybrid										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	61.55	61.91	61.07	60.53	60.28	60.97	61.37	61.55	61.49	61.43
Compact Cars	51.14	51.53	50.80	50.38	50.21	50.91	51.36	51.60	51.68	51.76
Midsize Cars	48.03	48.35	47.72	47.45	47.41	48.56	49.48	50.05	50.50	50.96
Large Cars	44.46	44.94	44.41	44.23	44.30	45.90	47.33	48.41	49.33	50.27
2-Seater Cars	46.61	46.99	46.52	46.49	46.70	48.85	50.92	52.45	53.85	55.29
Small Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Van	38.03	38.61	38.28	38.18	38.33	38.68	38.80	38.90	39.33	39.78
Large Van	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Utility	35.61	36.19	35.93	35.91	36.15	36.77	37.21	37.50	38.23	38.97
Large Utility	28.75	29.20	29.01	29.05	29.28	29.91	30.54	30.96	31.75	32.56
Fuel Cell Methanol										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	53.73	53.42	52.71	52.34	52.06	51.30	50.69	50.18	49.11	48.06
Midsize Cars	46.74	46.66	46.07	45.75	45.51	44.90	44.57	44.21	43.39	42.59
Large Cars	42.04	41.70	41.22	40.97	40.78	40.10	39.55	39.26	38.41	37.58
2-Seater Cars	50.14	49.82	49.12	48.72	48.42	47.53	46.83	46.37	45.24	44.13
Small Pickup	47.00	46.80	46.08	45.57	45.15	43.74	42.34	41.40	39.89	38.44
Large Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Van	40.53	40.59	40.03	39.62	39.28	38.12	36.86	36.03	34.87	33.75
Large Van	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cell Hydrogen										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	58.92	58.57	57.80	57.39	57.08	56.25	55.58	55.02	53.85	52.69
Midsize Cars	51.25	51.16	50.51	50.16	49.90	49.23	48.87	48.48	47.58	46.70
Large Cars	46.10	45.72	45.19	44.92	44.71	43.97	43.36	43.05	42.12	41.20
2-Seater Cars	54.98	54.62	53.86	53.43	53.09	52.11	51.35	50.84	49.60	48.39
Small Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Van	44.44	44.51	43.89	43.44	43.07	41.79	40.42	39.50	38.23	37.01
Large Van	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 57. New Light-Duty Vehicle Fuel Economy
(Miles per Gallon)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Fuel Cell Gasoline										
Minincompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subcompact Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compact Cars	50.35	50.05	49.39	49.04	48.78	48.07	47.50	47.02	46.01	45.03
Midsize Cars	43.80	43.72	43.17	42.87	42.65	42.07	41.76	41.43	40.66	39.91
Large Cars	39.40	39.07	38.62	38.39	38.21	37.57	37.06	36.79	35.99	35.21
2-Seater Cars	46.98	46.68	46.03	45.66	45.37	44.54	43.88	43.45	42.39	41.35
Small Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Pickup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Van	37.98	38.04	37.50	37.12	36.81	35.72	34.54	33.76	32.67	31.63
Large Van	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Utility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

N/A = Not applicable.

Note: The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1997 derived using: Energy and Environmental Analysis Inc., Updates to the Fuels Economy Model, prepared for Energy Information Administration (EIA) (Washington, DC, June 1998); National Highway Traffic and Safety Administration, Mid-Model Year Fuel Economy Reports for for Auto Manufacturers, 1998; and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projection: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 58. New Light-Duty Vehicle Prices
(Thousands 1990 Dollars)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Gasoline										
Minincompact Cars	28.4	28.5	28.7	28.7	28.7	28.7	29.0	29.2	29.49	29.77
Subcompact Cars	13.5	13.6	13.8	13.9	13.9	14.0	14.3	14.6	14.96	15.35
Compact Cars	16.9	17.0	17.3	17.3	17.3	17.5	17.7	18.0	18.39	18.77
Midsize Cars	19.2	19.2	19.5	19.5	19.6	19.6	19.8	20.0	20.33	20.66
Large Cars	22.8	22.9	23.2	23.2	23.2	23.2	23.2	23.4	23.68	23.94
2-Seater Cars	21.1	21.1	21.4	21.4	21.5	21.5	21.7	22.0	22.33	22.65
Small Pickup	13.4	13.4	13.7	13.7	13.7	13.7	13.9	14.2	14.41	14.67
Large Pickup	16.3	16.3	16.6	16.6	16.6	16.5	16.5	16.7	16.79	16.92
Small Van	19.1	19.2	19.5	19.5	19.5	19.5	19.6	19.9	20.16	20.45
Large Van	16.7	16.8	17.1	17.0	17.0	16.9	16.8	17.0	17.15	17.28
Small Utility	20.2	20.3	20.6	20.5	20.5	20.5	20.6	20.9	21.12	21.36
Large Utility	19.0	19.0	19.2	19.2	19.2	19.2	19.2	19.4	19.50	19.65
Turbo Direct Injection Diesel										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	17.0	17.8	18.1	18.1	18.1	18.3	18.5	18.8	19.35	19.91
Midsize Cars	20.2	20.1	20.2	20.1	20.2	20.0	20.2	20.4	20.57	20.73
Large Cars	23.6	23.7	24.0	24.0	24.0	24.0	24.0	24.2	24.48	24.74
2-Seater Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Pickup	15.0	15.0	15.1	15.0	15.2	15.1	15.2	15.5	15.73	15.95
Large Pickup	18.8	18.7	18.8	18.6	19.1	19.0	18.9	19.1	19.22	19.34
Small Van	21.0	21.0	21.1	21.0	21.2	21.2	21.4	21.7	21.93	22.20
Large Van	19.1	19.2	19.5	19.4	19.4	19.3	19.2	19.3	19.44	19.55
Small Utility	22.3	22.2	22.3	22.1	22.3	22.0	22.2	22.4	22.48	22.56
Large Utility	24.7	24.6	24.7	24.5	25.0	24.9	24.9	25.1	25.22	25.37
Methanol										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	13.9	13.9	14.2	14.2	14.3	14.4	14.7	15.0	15.33	15.72
Compact Cars	17.4	17.5	17.8	17.8	17.9	17.6	18.1	18.4	18.72	19.07
Midsize Cars	20.1	20.2	20.5	20.5	20.5	20.3	20.1	20.4	20.63	20.82
Large Cars	23.2	23.3	23.6	23.6	23.6	23.6	23.6	23.8	24.05	24.31
2-Seater Cars	21.5	21.5	21.8	21.8	21.8	21.9	22.1	22.4	22.70	23.02
Small Pickup	14.9	14.9	15.2	15.1	15.1	15.2	15.4	15.7	15.93	16.21
Large Pickup	18.2	18.3	18.5	18.5	18.5	18.4	18.4	18.6	18.73	18.87
Small Van	20.9	20.9	21.2	21.1	21.1	21.2	21.3	21.6	21.91	22.20
Large Van	18.6	18.6	18.9	18.9	18.8	18.7	18.7	18.8	18.96	19.08
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methanol Flex										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	13.9	14.0	14.2	14.3	14.3	14.4	14.7	15.0	15.37	15.76
Compact Cars	17.3	17.4	17.7	17.7	17.8	17.9	18.1	18.4	18.79	19.18
Midsize Cars	19.6	19.7	19.9	20.0	20.0	20.0	20.2	20.1	20.34	20.58
Large Cars	23.2	23.3	23.6	23.6	23.6	23.6	23.6	23.8	24.09	24.35
2-Seater Cars	21.5	21.6	21.8	21.8	21.9	21.9	22.1	22.4	22.74	23.06
Small Pickup	14.5	14.5	14.8	14.8	14.8	15.0	15.5	15.8	16.11	16.43
Large Pickup	18.2	18.2	18.5	18.5	18.5	18.6	18.6	18.8	18.92	19.06
Small Van	21.0	21.0	21.3	21.3	21.3	21.3	21.5	21.8	22.06	22.35
Large Van	18.7	18.8	19.1	19.0	19.0	18.9	18.8	19.0	19.15	19.28
Small Utility	21.3	21.3	21.6	21.6	21.5	21.6	21.7	22.2	22.41	22.62
Large Utility	24.3	24.3	24.6	24.6	24.6	24.6	24.5	24.8	24.94	25.11
Ethanol										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	13.9	13.9	14.2	14.2	14.3	14.4	14.7	15.0	15.33	15.72
Compact Cars	17.4	17.5	17.8	17.8	17.9	18.0	18.1	18.6	18.95	19.35
Midsize Cars	20.1	20.2	20.5	20.5	20.5	20.6	20.6	20.9	21.26	21.58
Large Cars	23.2	23.3	23.6	23.6	23.6	23.6	23.6	23.8	24.05	24.31
2-Seater Cars	21.5	21.5	21.8	21.8	21.8	21.9	22.1	22.4	22.70	23.02
Small Pickup	14.9	14.9	15.2	15.1	15.1	15.2	15.4	15.7	15.93	16.21
Large Pickup	18.2	18.3	18.5	18.5	18.5	18.4	18.4	18.6	18.74	18.87

Table 58. New Light-Duty Vehicle Prices
(Thousands 1990 Dollars)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Small Van	20.9	20.9	21.2	21.2	21.1	21.2	21.3	21.6	21.92	22.21
Large Van	18.6	18.6	18.9	18.9	18.8	18.7	18.7	18.8	18.96	19.09
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ethanol Flex										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	13.9	14.0	14.2	14.3	14.3	14.4	14.7	15.0	15.37	15.76
Compact Cars	17.3	17.4	17.7	17.7	17.8	17.9	18.1	18.4	18.79	19.18
Midsize Cars	19.6	19.7	19.9	20.0	20.0	19.7	20.0	20.4	20.75	21.13
Large Cars	23.2	23.3	23.6	23.6	23.6	23.6	23.6	23.8	24.09	24.35
2-Seater Cars	21.5	21.6	21.8	21.8	21.9	21.9	22.1	22.4	22.74	23.06
Small Pickup	14.6	14.6	14.9	14.8	14.9	15.1	15.5	15.8	16.09	16.38
Large Pickup	18.3	18.3	18.6	18.6	18.6	18.6	18.6	18.8	18.92	19.06
Small Van	21.0	21.0	21.3	21.3	21.3	21.3	21.5	21.8	22.06	22.35
Large Van	18.7	18.8	19.1	19.0	19.0	18.9	18.8	19.0	19.15	19.28
Small Utility	21.6	21.6	21.8	21.8	21.8	21.8	22.1	22.6	22.86	23.09
Large Utility	24.3	24.3	24.6	24.6	24.6	24.6	24.5	24.8	24.94	25.12
Compressed Natural Gas (CNG)										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	20.7	20.8	21.1	21.1	21.1	21.2	21.5	21.8	22.18	22.56
Midsize Cars	23.5	23.6	23.9	23.9	23.9	23.9	24.1	24.3	24.63	24.94
Large Cars	24.8	24.9	25.2	25.2	25.2	24.9	24.6	24.8	24.91	25.02
2-Seater Cars	21.3	21.4	21.7	21.6	21.7	21.6	23.4	23.7	24.43	25.18
Small Pickup	18.3	18.3	18.6	18.6	18.6	18.6	18.7	19.0	19.26	19.52
Large Pickup	21.8	21.8	22.1	22.0	22.0	21.9	21.8	22.0	22.12	22.23
Small Van	24.3	24.3	24.6	24.5	24.5	24.5	24.6	24.9	25.21	25.47
Large Van	22.1	22.1	22.4	22.4	22.4	22.2	22.1	22.2	22.34	22.43
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CNG Bi-Fuel										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	21.7	21.8	22.1	22.1	22.1	22.2	22.5	22.8	23.18	23.56
Midsize Cars	24.5	24.6	24.9	24.9	24.9	24.9	25.1	25.3	25.63	25.94
Large Cars	25.8	25.9	26.2	26.2	26.2	25.9	25.6	25.8	25.91	26.02
2-Seater Cars	22.3	22.4	22.7	22.6	22.7	22.6	24.4	24.7	25.43	26.17
Small Pickup	19.3	19.3	19.6	19.6	19.6	19.6	19.7	20.0	20.26	20.52
Large Pickup	22.8	22.8	23.1	23.0	23.0	22.9	22.8	23.0	23.12	23.23
Small Van	25.3	25.3	25.6	25.5	25.5	25.5	25.6	25.9	26.21	26.47
Large Van	23.1	23.1	23.4	23.4	23.4	23.2	23.1	23.2	23.34	23.43
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liquefied Petroleum Gas (LPG)										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	15.6	15.7	15.9	16.0	16.0	16.2	16.4	16.7	17.13	17.54
Compact Cars	19.6	19.6	19.9	19.9	20.0	20.1	20.4	20.7	21.09	21.49
Midsize Cars	23.0	23.0	23.3	23.3	23.4	23.4	23.6	23.9	24.19	24.52
Large Cars	24.3	24.4	24.7	24.7	24.7	24.7	24.7	24.9	25.12	25.37
2-Seater Cars	22.0	22.1	22.3	22.4	22.4	22.4	22.7	22.9	23.25	23.57
Small Pickup	17.8	17.8	18.0	18.0	18.0	18.1	18.2	18.5	18.82	19.09
Large Pickup	21.9	21.9	22.2	22.2	22.1	22.1	22.0	22.2	22.34	22.48
Small Van	23.7	23.8	24.1	24.0	24.0	24.0	24.2	24.5	24.78	25.07
Large Van	22.2	22.2	22.5	22.5	22.5	22.4	22.3	22.4	22.57	22.69
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG Bi-Fuel										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	20.6	20.6	20.9	20.9	21.0	21.1	21.4	21.7	22.09	22.48

Table 58. New Light-Duty Vehicle Prices
(Thousands 1990 Dollars)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Midsize Cars	24.0	24.0	24.3	24.3	24.4	24.4	24.6	24.9	25.19	25.52
Large Cars	25.3	25.4	25.7	25.7	25.7	25.7	25.7	25.9	26.12	26.37
2-Seater Cars	23.0	23.1	23.3	23.4	23.4	23.4	23.7	23.9	24.25	24.57
Small Pickup	18.8	18.8	19.0	19.0	19.0	19.1	19.2	19.5	19.82	20.09
Large Pickup	22.9	22.9	23.2	23.2	23.1	23.1	23.0	23.2	23.34	23.48
Small Van	24.7	24.8	25.1	25.0	25.0	25.0	25.2	25.5	25.78	26.07
Large Van	23.2	23.2	23.5	23.5	23.5	23.4	23.3	23.4	23.57	23.69
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electric										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	27.8	28.2	28.9	29.2	29.5	29.1	28.2	28.5	28.58	28.68
Compact Cars	32.4	32.8	33.6	33.9	34.3	33.7	32.7	33.0	33.04	33.10
Midsize Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Seater Cars	33.4	23.8	24.6	25.0	25.4	24.8	23.8	24.0	22.25	20.60
Small Pickup	31.1	31.5	32.3	32.8	33.2	32.7	31.8	32.1	32.29	32.46
Large Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Van	37.9	38.4	39.2	39.7	40.1	39.6	38.4	38.9	38.96	39.07
Large Van	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diesel-Electric Hybrid										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	39.9	25.3	25.4	25.3	25.3	25.1	25.1	25.4	23.00	20.81
Compact Cars	46.8	29.7	29.9	29.8	29.7	29.4	29.3	29.7	26.80	24.21
Midsize Cars	52.4	32.9	33.0	32.9	32.7	32.3	32.1	32.4	29.07	26.09
Large Cars	56.7	34.8	34.9	34.7	34.6	33.9	33.6	33.9	30.15	26.84
2-Seater Cars	49.1	30.6	30.7	30.6	30.4	29.9	29.6	29.9	26.76	23.95
Small Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Van	57.2	34.5	34.6	34.4	34.2	33.6	33.3	33.6	29.82	26.46
Large Van	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Utility	59.7	36.2	36.3	36.1	35.9	35.3	34.9	35.2	31.20	27.69
Large Utility	67.9	39.2	39.3	39.0	38.8	37.9	37.3	37.6	32.87	28.75
Fuel Cell Methanol										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	0.0	0.0	0.0	74.8	68.2	49.6	37.7	32.3	24.43	18.48
Midsize Cars	0.0	0.0	0.0	84.2	76.7	55.4	41.8	35.5	26.66	20.01
Large Cars	0.0	0.0	0.0	92.0	83.5	59.8	44.7	37.6	27.95	20.77
2-Seater Cars	0.0	0.0	0.0	78.9	71.9	52.0	39.2	33.2	24.94	18.72
Small Pickup	0.0	0.0	0.0	79.7	72.4	51.3	37.7	31.2	22.81	16.70
Large Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Van	0.0	0.0	0.0	93.6	85.0	60.9	45.2	37.7	27.90	20.63
Large Van	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cell Hydrogen										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	0.0	0.0	0.0	65.4	60.8	47.9	39.7	36.0	29.53	24.23
Midsize Cars	0.0	0.0	0.0	72.8	67.5	52.7	43.3	39.0	31.74	25.81
Large Cars	0.0	0.0	0.0	78.6	72.7	56.2	45.7	40.9	32.94	26.53
2-Seater Cars	0.0	0.0	0.0	68.5	63.6	49.7	40.9	36.8	29.99	24.41
Small Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Van	0.0	0.0	0.0	79.5	73.6	56.8	46.0	40.8	32.74	26.24
Large Van	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 58. New Light-Duty Vehicle Prices
(Thousands 1990 Dollars)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Fuel Cell Gasoline										
Minincompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subcompact Cars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compact Cars	0.0	0.0	0.0	82.1	74.5	53.1	39.4	33.0	24.43	18.06
Midsize Cars	0.0	0.0	0.0	92.6	83.9	59.3	43.6	36.4	26.68	19.56
Large Cars	0.0	0.0	0.0	101.3	91.5	64.2	46.7	38.6	28.00	20.32
2-Seater Cars	0.0	0.0	0.0	86.8	78.7	55.7	40.9	34.1	24.97	18.31
Small Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Pickup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Van	0.0	0.0	0.0	103.2	93.4	65.5	47.4	38.8	28.02	20.24
Large Van	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large Utility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

N/A = Not applicable.

Note: The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1998 derived using: Energy and Environmental Analysis Inc., Updates to the Fuels Economy Model, prepared for Energy Information Administration (EIA) (Washington, DC, June 1998); and and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projection: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 59. New Light-Duty Vehicle Range (Miles)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Gasoline										
Minincompact Cars	486	500	500	505	511	529	535	537	554.41	571.98
Subcompact Cars	476	485	485	486	488	498	497	492	499.23	506.14
Compact Cars	474	487	487	488	491	503	505	501	511.18	521.37
Midsize Cars	472	482	482	484	487	503	507	507	518.49	530.48
Large Cars	515	529	529	532	537	559	572	575	593.62	612.55
2-Seater Cars	477	489	489	492	497	511	515	514	526.94	539.77
Small Pickup	418	421	419	418	418	419	427	432	437.29	442.29
Large Pickup	401	404	402	403	407	415	432	444	455.55	467.00
Small Van	481	486	486	487	489	491	501	512	523.22	534.18
Large Van	454	462	462	466	472	488	509	527	550.43	574.77
Small Utility	428	434	433	433	436	443	455	464	475.40	487.47
Large Utility	416	422	422	425	431	447	464	478	496.67	516.57
Turbo Direct Injection Diesel										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	615	632	631	632	635	648	648	641	651.58	661.93
Midsize Cars	641	655	654	657	662	680	683	682	695.79	710.36
Large Cars	709	729	729	732	739	769	785	790	814.38	839.51
2-Seater Cars	0	0	0	0	0	0	0	0	0	0
Small Pickup	567	573	571	569	570	574	585	589	597.47	605.68
Large Pickup	546	549	546	549	553	565	587	605	619.81	635.38
Small Van	605	613	611	611	614	623	639	645	658.84	672.49
Large Van	613	624	623	629	638	659	687	712	743.07	775.94
Small Utility	565	572	571	571	575	586	603	611	626.82	642.71
Large Utility	660	669	670	675	685	709	737	758	788.61	820.21
Methanol										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	299	305	305	305	306	311	310	307	310.60	314.12
Compact Cars	287	295	294	295	296	303	302	299	304.07	308.90
Midsize Cars	299	306	305	306	309	317	319	318	324.70	331.50
Large Cars	331	340	340	342	345	359	366	369	380.05	391.77
2-Seater Cars	291	300	301	305	309	322	329	333	345.98	359.83
Small Pickup	265	267	266	266	266	268	273	275	278.82	282.65
Large Pickup	255	256	255	256	258	264	274	282	289.24	296.51
Small Van	282	286	285	285	286	291	298	301	307.46	313.83
Large Van	286	291	291	293	298	307	321	332	346.77	362.10
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
Methanol Flex										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	271	276	276	276	277	282	281	278	281.02	284.21
Compact Cars	260	267	266	267	268	274	273	271	275.11	279.48
Midsize Cars	271	276	276	277	279	287	288	288	293.78	299.93
Large Cars	299	308	308	309	312	325	332	334	343.85	354.46
2-Seater Cars	263	272	273	276	279	292	298	301	313.03	325.56
Small Pickup	240	242	241	240	241	243	247	249	252.27	255.73
Large Pickup	230	232	231	232	234	239	248	255	261.70	268.27
Small Van	255	259	258	258	259	263	270	273	278.18	283.94
Large Van	259	263	263	265	269	278	290	300	313.74	327.62
Small Utility	238	242	241	241	243	247	255	258	264.66	271.37
Large Utility	279	283	283	285	289	300	311	320	332.97	346.31
Ethanol										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	361	368	368	368	369	375	374	370	374.69	378.94
Compact Cars	346	356	355	356	358	365	365	361	366.81	372.64
Midsize Cars	361	369	368	370	372	383	385	384	391.71	399.91
Large Cars	399	410	410	412	416	433	442	445	458.47	472.61
2-Seater Cars	351	362	363	368	373	389	397	401	417.37	434.08
Small Pickup	319	322	321	320	321	323	330	332	336.36	340.98
Large Pickup	307	309	308	309	312	318	331	340	348.93	357.69

Table 59. New Light-Duty Vehicle Range (Miles)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Small Van	341	345	344	344	346	351	360	363	370.90	378.59
Large Van	345	351	351	354	359	371	387	401	418.32	436.82
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
Ethanol Flex										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	347	353	353	353	354	361	360	356	359.90	363.98
Compact Cars	333	342	341	342	343	351	350	347	352.33	357.93
Midsize Cars	346	354	354	355	358	368	369	369	376.24	384.12
Large Cars	383	394	394	396	399	416	425	427	440.37	453.96
2-Seater Cars	337	348	349	353	358	374	382	385	400.90	416.94
Small Pickup	307	310	309	308	308	311	316	319	323.08	327.52
Large Pickup	295	297	296	297	299	306	318	327	335.16	343.58
Small Van	327	331	331	330	332	337	346	349	356.26	363.64
Large Van	332	337	337	340	345	356	372	385	401.81	419.58
Small Utility	305	310	309	309	311	317	326	331	338.95	347.54
Large Utility	357	362	362	365	370	384	399	410	426.43	443.52
Compressed Natural Gas (CNG)										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	273	281	280	281	282	288	288	285	289.59	294.19
Midsize Cars	285	291	291	292	294	302	304	303	309.24	315.72
Large Cars	315	324	324	325	328	342	349	351	361.95	373.11
2-Seater Cars	277	286	287	290	294	307	314	317	329.51	342.69
Small Pickup	252	254	254	253	253	255	260	262	265.54	269.19
Large Pickup	243	244	243	244	246	251	261	269	275.47	282.39
Small Van	269	272	272	271	273	277	284	287	292.82	298.88
Large Van	273	277	277	279	283	293	306	316	330.26	344.86
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
CNG Bi-Fuel										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	228	234	234	234	235	240	240	238	241.32	245.16
Midsize Cars	237	243	242	243	245	252	253	252	257.70	263.10
Large Cars	263	270	270	271	274	285	291	293	301.62	310.93
2-Seater Cars	231	238	239	242	245	256	261	264	274.59	285.58
Small Pickup	210	212	211	211	211	213	217	218	221.29	224.33
Large Pickup	202	203	202	203	205	209	217	224	229.56	235.33
Small Van	224	227	226	226	227	231	237	239	244.02	249.07
Large Van	227	231	231	233	236	244	255	264	275.21	287.38
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
Liquefied Petroleum Gas (LPG)										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	404	411	411	411	413	420	419	414	419.07	423.82
Compact Cars	387	398	397	398	400	408	408	404	410.25	416.77
Midsize Cars	403	412	412	413	417	428	430	429	438.09	447.26
Large Cars	446	459	459	461	465	484	494	497	512.76	528.58
2-Seater Cars	393	405	406	411	417	435	445	449	466.80	485.48
Small Pickup	357	361	359	358	359	362	369	371	376.19	381.36
Large Pickup	344	346	344	345	348	356	370	381	390.25	400.05
Small Van	381	386	385	385	386	392	402	406	414.83	423.42
Large Van	386	393	392	396	401	415	433	448	467.86	488.55
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
LPG Bi-Fuel										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	364	374	374	374	376	384	384	380	386.12	392.25

Table 59. New Light-Duty Vehicle Range (Miles)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Midsize Cars	380	388	388	389	392	403	405	404	412.32	420.95
Large Cars	420	432	432	434	438	455	465	468	482.60	497.49
2-Seater Cars	370	381	382	387	392	409	418	422	439.34	456.93
Small Pickup	336	339	338	337	338	340	347	349	354.06	358.92
Large Pickup	323	325	324	325	328	335	348	358	367.29	376.52
Small Van	358	363	362	362	364	369	379	383	390.43	398.51
Large Van	364	370	369	372	378	390	407	422	440.34	459.81
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
Electric										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	80	80	80	80	80	80	80	80	80	80
Compact Cars	80	80	80	80	80	80	80	80	80	80
Midsize Cars	0	0	0	0	0	0	0	0	0	0
Large Cars	0	0	0	0	0	0	0	0	0	0
2-Seater Cars	80	80	80	80	80	80	80	80	80	80
Small Pickup	80	80	80	80	80	80	80	80	80	80
Large Pickup	0	0	0	0	0	0	0	0	0	0
Small Van	80	80	80	80	80	80	80	80	80	80
Large Van	0	0	0	0	0	0	0	0	0	0
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
Diesel-Electric Hybrid										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	618	629	629	629	631	642	640	634	640.92	648.19
Compact Cars	592	608	608	608	612	624	624	618	627.44	637.41
Midsize Cars	617	631	630	632	637	654	658	656	670.02	684.05
Large Cars	683	702	702	705	711	740	756	761	784.22	808.41
2-Seater Cars	601	620	622	629	637	665	680	686	713.93	742.50
Small Pickup	0	0	0	0	0	0	0	0	0	0
Large Pickup	0	0	0	0	0	0	0	0	0	0
Small Van	582	590	589	588	591	600	615	622	634.44	647.58
Large Van	0	0	0	0	0	0	0	0	0	0
Small Utility	544	551	550	550	553	564	581	589	603.60	618.91
Large Utility	636	645	645	650	659	683	710	730	759.40	789.83
Fuel Cell Methanol										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	456	468	467	468	470	480	480	475	482.65	490.32
Midsize Cars	475	485	485	486	490	503	506	505	515.40	526.19
Large Cars	525	540	540	542	547	569	582	585	603.25	621.86
2-Seater Cars	462	477	478	484	490	512	523	528	549.18	571.16
Small Pickup	420	424	423	421	422	425	434	437	442.57	448.65
Large Pickup	0	0	0	0	0	0	0	0	0	0
Small Van	448	454	453	452	455	461	473	478	488.03	498.14
Large Van	0	0	0	0	0	0	0	0	0	0
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0
Fuel Cell Hydrogen										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	456	468	467	468	470	480	480	475	482.65	490.32
Midsize Cars	475	485	485	486	490	503	506	505	515.40	526.19
Large Cars	525	540	540	542	547	569	582	585	603.25	621.86
2-Seater Cars	462	477	478	484	490	512	523	528	549.18	571.16
Small Pickup	0	0	0	0	0	0	0	0	0	0
Large Pickup	0	0	0	0	0	0	0	0	0	0
Small Van	448	454	453	452	455	461	473	478	488.03	498.14
Large Van	0	0	0	0	0	0	0	0	0	0
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0

Table 59. New Light-Duty Vehicle Range (Miles)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Fuel Cell Gasoline										
Minincompact Cars	0	0	0	0	0	0	0	0	0	0
Subcompact Cars	0	0	0	0	0	0	0	0	0	0
Compact Cars	456	468	467	468	470	480	480	475	482.65	490.32
Midsize Cars	475	485	485	486	490	503	506	505	515.40	526.19
Large Cars	525	540	540	542	547	569	582	585	603.25	621.86
2-Seater Cars	462	477	478	484	490	512	523	528	549.18	571.16
Small Pickup	0	0	0	0	0	0	0	0	0	0
Large Pickup	0	0	0	0	0	0	0	0	0	0
Small Van	448	454	453	452	455	461	473	478	488.03	498.14
Large Van	0	0	0	0	0	0	0	0	0	0
Small Utility	0	0	0	0	0	0	0	0	0	0
Large Utility	0	0	0	0	0	0	0	0	0	0

N/A = Not applicable.

Note: The historical data used for the projections were the most available as of July 31, 1999. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.

Sources: 1998 derived using: Energy and Environmental Analysis Inc., Updates to the Fuels Economy Model, prepared for Energy Information Administration (EIA) (Washington, DC, June 1998); and and EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A. Projection: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 73. Electric Power Projections for EMM Region
Unites States Total

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity Generating Capacity 1/										
(gigawatts)										
Coal Steam	306.36	303.52	301.66	301.62	301.76	301.66	306.80	316.95	319.69	322.45
Other Fossil Steam 2/	136.87	130.15	126.93	125.29	123.01	119.52	117.07	109.87	104.29	99.00
Combined Cycle	31.60	35.47	46.42	55.75	64.14	93.05	124.71	154.64	247.70	396.76
Combustion Turbine/Diesel	89.01	100.17	104.16	115.01	122.29	153.48	180.44	202.29	254.90	321.19
Nuclear Power	97.46	94.99	93.40	93.40	89.01	84.14	67.35	56.97	50.46	44.70
Pumped Storage/Other 3/	19.93	19.98	20.02	20.02	20.02	20.02	20.02	20.02	20.05	20.09
Fuel Cells	0.00	0.01	0.01	0.02	0.02	0.04	0.05	0.07	0.23	0.76
Renewable 4/	89.96	90.27	90.70	91.13	91.74	93.84	95.33	96.67	98.96	101.31
Total Capability	771.19	774.54	783.29	802.24	811.99	865.75	911.76	957.47	1015.17	1076.34
Cumulative Planned Additions 5/										
Coal Steam	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08		
Other Fossil Steam 2/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Combined Cycle	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69		
Combustion Turbine/Diesel	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47		
Nuclear Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Pumped Storage/Other 3/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Fuel Cells	0.00	0.01	0.01	0.02	0.02	0.04	0.05	0.07		
Renewable 4/	1.80	2.02	2.41	2.67	3.16	4.78	5.73	5.92		
Total (planned)	8.04	8.27	8.66	8.93	9.43	11.06	12.02	12.23		
Cumulative Unplanned Additions 5/										
Coal Steam	0.02	0.02	0.13	0.72	1.12	3.78	9.53	20.97		
Other Fossil Steam 2/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Combined Cycle	7.44	11.30	22.30	31.63	40.02	68.93	100.59	130.52		
Combustion Turbine/Diesel	14.40	26.16	30.42	42.19	49.80	81.90	109.35	132.33		
Nuclear Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Pumped Storage/Other 3/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Fuel Cells	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Renewable 4/	0.82	0.90	0.97	1.07	1.15	1.77	2.60	3.75		
Total (unplanned)	22.68	38.38	53.83	75.61	92.10	156.39	222.07	287.57		
Cumulative Total Additions	30.72	46.65	62.49	84.54	101.52	167.45	234.09	299.80		
Cumulative Retirements	4.62	17.84	25.63	28.88	36.25	48.41	69.03	89.03		
Cogenerators 6/										
Capacity										
Coal	8.98	8.98	8.98	8.98	8.98	8.98	8.97	8.97	9.01	9.05
Petroleum	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.33	1.33
Natural Gas	35.39	35.51	35.62	35.75	35.86	36.42	37.34	38.42	40.11	41.88
Other Gaseous Fuels	0.74	0.74	0.75	0.76	0.76	0.81	0.88	0.96	1.15	1.38
Renewables	8.04	8.21	8.38	8.55	8.69	9.21	9.78	10.31	11.04	11.81
Other	0.12	0.12	0.12	0.12	0.12	0.13	0.14	0.15	0.18	0.21
Total	54.59	54.88	55.16	55.47	55.73	56.86	58.44	60.14	62.71	65.38
Electricity Demand										
(billion kilowatthours)										
Residential	1221.15	1239.63	1258.95	1280.18	1298.32	1377.86	1463.30	1547.60	1665.67	1792.74
Commercial/Other	1135.66	1151.27	1167.92	1188.04	1204.40	1276.01	1342.59	1369.32	1457.97	1552.35
Industrial	1079.91	1105.43	1125.78	1147.85	1163.39	1216.05	1301.16	1376.39	1466.53	1562.58
Transportation	20.33	22.52	24.64	26.58	28.33	34.64	41.34	39.41	46.87	55.74
Total Sales	3457.04	3518.85	3577.29	3642.65	3694.43	3904.56	4148.39	4332.72	4635.58	4959.60
Net Energy for Load (billion kwh) 7/										
Gross International Imports	66.16	69.97	66.52	63.51	66.43	43.83	31.59	27.93	25.01	22.39
Gross International Exports	15.17	20.49	20.60	20.72	20.85	18.10	12.60	7.66	6.54	5.58
Gross Interregional Electric Imports	344.15	349.16	354.91	345.25	339.87	297.96	227.27	182.35	157.90	136.73
Gross Interregional Electric Exports	348.04	353.38	359.30	349.57	344.31	302.11	230.93	186.07	161.56	140.27
Purchases from cogenerators 6/	145.72	146.71	147.73	148.82	149.85	154.24	160.68	166.71	171.67	176.78
Util. Generation for Customers	3488.08	3551.68	3614.54	3680.38	3728.97	3957.50	4206.09	4392.48	4694.76	5017.84
Total Net Energy for Load	3680.90	3743.65	3803.80	3867.66	3919.97	4133.33	4382.09	4575.75	4878.69	5201.69

Table 73. Electric Power Projections for EMM Region
Unites States Total

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Generation by Fuel Type										
(billion kilowatthours)										
Coal	1973.27	2015.32	2058.04	2076.23	2088.90	2121.49	2200.20	2295.73	2420.96	2553.03
Petroleum	73.78	68.10	64.83	62.29	63.99	47.99	40.99	37.21	28.86	22.39
Natural Gas	405.32	432.31	462.81	516.95	566.58	796.17	1085.11	1256.23	1708.18	2322.73
Nuclear	691.48	690.67	680.78	674.38	656.08	627.33	510.60	427.07	385.03	347.14
Pumped Storage/Other 3/	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.76	-0.63
Renewable 4/	359.09	360.23	363.43	366.13	369.52	381.33	386.26	393.32	401.31	409.47
Total Generation	3502.02	3565.71	3628.97	3695.06	3744.15	3973.39	4222.24	4408.63	4712.65	5037.64
Sales to Customers	3488.08	3551.68	3614.54	3680.38	3728.97	3957.50	4206.09	4392.48	4694.76	5017.84
Generation for Own Use	13.95	14.03	14.43	14.68	15.18	15.88	16.15	16.15	17.96	19.98
Cogenerators										
Coal	51.29	51.35	51.40	51.43	51.40	51.33	51.33	51.29	51.10	50.92
Petroleum	6.12	6.13	6.13	6.16	6.17	6.25	6.39	6.59	6.37	6.16
Natural Gas	196.89	197.76	198.58	199.58	200.45	204.73	212.24	220.35	226.55	232.93
Other Gaseous Fuels	5.76	5.82	5.84	5.93	5.97	6.24	6.80	7.32	8.88	10.78
Renewable	47.34	48.33	49.25	50.18	50.91	53.57	56.79	59.55	62.65	65.91
Other	7.92	7.93	7.93	7.95	7.95	8.00	8.08	8.17	8.28	8.40
Total	315.31	317.31	319.14	321.22	322.84	330.11	341.63	353.27	363.06	373.12
Sales to Utilities	145.72	146.71	147.73	148.82	149.85	154.24	160.68	166.71	171.67	176.78
Generation for Own Use	169.59	170.60	171.41	172.40	173.00	175.87	180.95	186.56	191.40	196.36
End-Use Prices										
(1998 cents per kilowatthour)										
Residential	7.6	7.6	7.6	7.5	7.5	7.4	7.3	7.3	7.11	6.95
Commercial	6.9	6.8	6.7	6.6	6.6	6.4	6.3	6.2	5.95	5.71
Industrial	4.3	4.2	4.1	4.1	4.1	4.0	3.9	3.8	3.72	3.59
Transportation	5.2	5.2	5.1	5.0	5.0	4.8	4.7	4.6	4.36	4.16
All Sectors Average	6.3	6.2	6.2	6.1	6.1	6.0	5.9	5.8	5.64	5.47
Price Components										
(1998 cents per kilowatthour)										
Capital Component	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.71	2.59
Fuel Component	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.39	1.45
O&M Component	1.9	1.8	1.8	1.8	1.8	1.8	1.6	1.5	1.47	1.40
Wholesale Power Cost	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.08
Total	6.3	6.2	6.2	6.1	6.1	6.0	5.9	5.8	5.64	5.47
Fuel Consumption (quadrillion Btu) 8/										
Coal	20.67	21.19	21.65	21.84	21.97	22.25	22.97	23.72	25.01	26.37
Natural Gas	4.00	4.19	4.26	4.62	4.97	6.60	8.55	9.46	11.67	14.41
Oil	0.81	0.75	0.71	0.68	0.70	0.53	0.46	0.42	0.33	0.26
Total	25.48	26.12	26.62	27.15	27.64	29.37	31.97	33.60	36.35	39.32
Emissions(million short tons) 9/										
Carbon Dioxide	2427.04	2483.55	2532.53	2571.59	2606.89	2714.68	2895.78	3024.43	3239.53	3469.93
Sulfur Dioxide	11.05	10.85	10.65	10.38	10.12	9.15	8.95	8.95	8.22	7.54
Nitrogen Oxide	5.23	5.37	5.45	5.50	5.54	5.66	5.87	5.93	5.92	5.91

1/ Net summer capability is the steady hourly output that generating equipment is expected to supply to system load (exclusive of auxiliary power), as demonstrated by tests during summer peak demand. Includes electric utilities, small power producers, and exempt wholesale generators. Nameplate capacity is reported for nonutilities on Form EIA-867, signated by the manufacturer. The nameplate capacity has been converted to net summer capacity based on historic relationships.

2/ Includes oil-, gas-, and dual-fired capability.

3/ Other includes methane, propane gas, and blast furnace gas, hydrogen, sulfur, batteries, chemicals, fish oil, and spent sulfite liquor.

4/ Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, other biomass, solar thermal, photovoltaics, and wind power.

5/ Cumulative additions after December 31, 1999.

6/ Cogenerators produce electricity and another form of useful energy (such as steam or heat) through the sequential use of energy.

7/ Generation to meet system load by source.

8/ Includes fuel consumption by electric utilities, small power producers, independent power producers, and exempt wholesale generators. Differs from Electric Generators consumption in Table 2 of the Annual Energy Outlook 2000 and Tables 1 to 10 of the Supplement to the Annual Energy Outlook 2000 due to different definitions of electric generators.

Table 73. Electric Power Projections for EMM Region
Unites States Total

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030

9/ Estimated emissions from utilities and nonutilities (excluding cogenerators).
O&M = Operation and maintenance.
EMM = Electricity market module.
Kwh = Kilowatthour.
N/A = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most current available as of July 31, 1999.
The numbers presented for 1998 are estimates and may differ from official EIA data reports.
Also, please see EIA data publications and the Short-Term Energy Outlook for the 'latest estimates for 1999.
Source: 1998 (except for prices and nonutility data) Energy Information Administration (EIA), Annual Energy Review 1998, DOE/EIA-0384(98) (Washington, DC, July 1999).
Other 1998 and projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 76. Renewable Resources Consumption/Displacement by Source for Electricity
(Trillion Btu)

	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
United States										
Conventional Hydropower	3084.42	3087.69	3089.03	3090.33	3094.34	3089.10	3082.99	3077.34	3037.99	2999.15
Geothermal 1/	444.67	443.78	442.88	446.43	440.04	508.83	584.46	740.15	853.78	984.86
MSW	373.87	382.94	395.29	407.64	424.37	490.13	552.74	571.41	669.57	784.60
Biomass 2/	108.20	108.36	124.08	135.24	147.68	181.31	162.48	167.54	210.70	264.99
Solar Thermal 3/	9.26	9.33	9.74	9.81	9.99	11.25	12.58	13.91	15.29	16.80
Solar Photovoltaic 3/	0.59	0.96	1.33	1.81	2.31	4.70	8.87	13.41	53.34	212.17
Wind	70.16	73.67	79.88	84.10	92.13	112.57	122.06	124.30	165.97	221.60

1/ Includes hydrothermal resources only (hot water and steam).
2/ Include projections for energy crops beginning in 2010.
3/ Grid connected generation only.
Btu = British Thermal Unit.
MSW = Municipal solid waste.
Notes: Totals may not equal sum of components due to independent rounding. The historical data used for the projections were the most available as of July 31, 1999. At that time, most regional data for 1998 were not available. The numbers presented for 1998 are estimates and may differ from official EIA data reports. Also. please see EIA data publications and the Short-Term Energy Outlook for the latest estimates for 1999.
Source: Energy Information Administration, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Table 17. Renewable Energy Generating Capability and Generation
(Gigawatts, Unless Otherwise Noted)

	2001	2002	2003	2004	2005	2006	2010	2015	2020	2025	2030
Electricity Generators (excludes cogenerators) 1/											
Net Summer Capability											
Conventional Hydropower	77.79	77.94	78.06	78.13	78.21	78.35	78.33	78.33	78.33	78.47	78.61
Geothermal 2/	3.11	3.05	2.97	2.88	2.89	2.79	2.98	3.11	3.75	3.98	4.22
Municipal Solid Waste 3/	3.27	3.40	3.48	3.59	3.70	3.86	4.47	5.00	5.17	6.10	7.20
Wood and Other Biomass 4/	1.87	1.94	1.96	1.99	2.01	2.05	2.41	2.71	2.93	3.29	3.70
Solar Thermal	0.33	0.33	0.34	0.35	0.35	0.36	0.40	0.44	0.48	0.52	0.56
Solar Photovoltaic	0.02	0.02	0.04	0.05	0.07	0.09	0.19	0.35	0.52	1.22	2.84
Wind	2.90	3.27	3.43	3.71	3.89	4.24	5.07	5.40	5.49	6.91	8.70
Total	89.29	89.96	90.27	90.70	91.13	91.74	93.84	95.33	96.67	98.96	101.31
Generation (billion kilowatthours)											
Conventional Hydropower	299.79	300.04	300.36	300.49	300.62	301.01	300.50	299.90	299.35	295.52	291.75
Geothermal 2/	15.65	15.76	15.61	15.46	15.55	15.26	17.35	19.62	24.70	27.98	31.69
Municipal Solid Waste 3/	22.50	23.37	23.93	24.71	25.48	26.52	30.63	34.55	35.71	41.85	49.04
Wood and Other Biomass 4/	11.92	12.14	12.16	13.92	15.18	16.57	20.35	18.23	18.80	23.64	29.74
Dedicated Plants	7.43	7.88	8.04	8.21	8.38	8.64	11.00	13.03	14.55	17.27	20.49
Cofiring	4.49	4.26	4.12	5.72	6.80	7.93	9.34	5.20	4.25	5.20	6.36
Solar Thermal	0.89	0.90	0.91	0.95	0.95	0.97	1.09	1.22	1.35	1.49	1.63
Solar Photovoltaic	0.05	0.06	0.09	0.13	0.18	0.22	0.46	0.86	1.30	5.19	20.64
Wind	5.97	6.82	7.17	7.77	8.18	8.96	10.95	11.87	12.09	16.14	21.56
Total	356.78	359.09	360.23	363.43	366.13	369.52	381.33	386.26	393.32	401.31	409.47
Cogenerators 5/											
Net Summer Capability											
Municipal Solid Waste	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Biomass	6.26	6.40	6.56	6.71	6.85	6.96	7.37	7.94	8.46	9.13	9.86
Total	6.78	6.92	7.08	7.23	7.37	7.48	7.89	8.46	8.98	9.65	10.36
Generation (billion kilowatthours)											
Municipal Solid Waste	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.16	3.20
Biomass	38.36	39.23	40.19	41.07	41.96	42.63	45.06	48.28	51.02	54.77	58.80
Total	41.50	42.36	43.33	44.20	45.09	45.76	48.19	51.41	54.15	57.90	61.91
Other Generators 6/											
Net Summer Capability											
Conventional Hydropower 7/	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar Photovolvaic	0.02	0.03	0.04	0.07	0.09	0.13	0.35	0.42	0.74	2.13	6.11
Total	1.11	1.12	1.14	1.16	1.19	1.22	1.44	1.52	1.84	2.06	2.32
Generation (billion kilowatthours)											
Conventional Hydropower 7/	4.87	4.87	4.86	4.86	4.86	4.86	4.85	4.84	4.83	4.41	4.02
Geothermal	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.13	0.24
Solar Photovolvaic	0.03	0.04	0.07	0.12	0.16	0.22	0.46	0.47	0.50	1.34	3.59
Total	4.96	4.98	5.00	5.05	5.09	5.15	5.38	5.37	5.40	5.05	4.72

1/ Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
2/ Includes hydrothermal resources only (hot water and steam).
3/ Includes landfill gas.
4/ Includes projections for energy crops after 2010.
5/ Cogenerators produce electricity and other useful thermal energy.
6/ Includes small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
7/ Represents own-use industrial hydroelectric power.
N/A = Not applicable.
Notes: Totals may not equal sum of components due to independent rounding. Data for 1997 and 1998 are model results and may differ slightly from official EIA data reports. Net summer capability has been estimated for nonutility generators for AEO2000. Net summer capability is used to be consistent with electric utility capacity estimates. Additional retirements are determined on the basis of the size and age of the units.
Sources: 1997 and 1998 electric utility capability: Energy Information Administration (EIA), Form EIA-860. "Annual Electric Generator Report." 1997 and 1998 nonutility and cogenerator capability: EIA, Form EIA-867, "Annual Nonutility Power Producer Report, 1997." 1997 and 1998 generation: EIA, Annual Energy Review 1998, DOE/EIA-0384(98) (Washington, DC, July 1999). Projections: EIA, AEO2000 National Energy Modeling System run AEO2K.D100199A.

Appendix C
Diffusion Curves

Appendix C
Technology Diffusion Models – Application to Selected Energy-Efficient Products for Buildings

Abstract

Diffusion models represent the principal forecasting method for determining potential market penetration for products that have not yet been introduced into the marketplace. Because this situation generally applies to the long-term forecasting horizon of technology assessment models, a means to credibly represent price and policy effects in diffusion models is a key factor in improving the usefulness of market assessment studies. The basic diffusion models assume that the cumulative market penetration follows a characteristic time path (usually in the form of an S-shaped curve).

Perhaps the dominant type of diffusion model is the mixed-influence model introduced by Bass (1969). The Bass model incorporates parameters that reflect both external (e.g., mass media communication) and internal influences (e.g., word of mouth). A study was conducted by Pacific Northwest National Laboratory (PNNL) to estimate Bass specification for ten selected energy-efficient products in buildings to help assess technologies supported by the U.S. Department of Energy's (DOE's) Office of Building Technology, State and Community Programs (BTS). This appendix summarizes the results of that study.

Scientific and Technical Approach

A study was conducted by PNNL to examine the historical market penetration for ten energy-efficient products related to the building sector. Diffusion models were estimated for each product, based on the specification proposed by Frank Bass (1969). The resulting models are intended to help assess technologies supported by DOE's BTS. This model development and empirical analysis are designed to generate more credible predictions of the adoption process of important energy-efficiency technologies in the buildings sector.

The basic Bass diffusion model, which is possibly the most widely used specification for analyzing market penetration, assumes that the potential market in which the new technology is penetrating is fixed. In reality, the potential market is usually growing in response to a falling price as the manufacturing process and industry structure behind the new technology evolve. This study is aimed toward developing a simple structural model that incorporates these effects and that can be easily estimated from historical data. Given a suitable conceptual model, its parameters can be estimated from data related to several energy technologies.

Most studies of technology adoption have focused either on defining the market potential of the new technology or on the pace by which the technology is adopted. Models that have integrated both aspects generally have not been subjected to historical validation of their underlying parameters. Therefore, in general, little empirical basis exists to suggest which process—diffusion or expanding market potential due to falling costs—might be more influential in driving the penetration of new technologies.

Background

A report by the Electric Power Research Institute (EPRI) (1991) provides a good overview of market penetration approaches. Although the report has a slant toward utilities, much of the discussion applies to all types of energy-saving technologies. The report was prepared by the Research Triangle Institute in North Carolina.

The EPRI report clearly distinguishes between two aspects of the process for forecasting market penetration: 1) forecasting market potential, and 2) forecasting the rate of market penetration. Forecasting market potential can involve several different concepts of potential, including maximum, technical, and economic potential.

The EPRI report states that the factors affecting the rate of market penetration are predominantly different from factors affecting market potential. For example, comparative advantage—often determined by economic cost—strongly affects market potential. However, comparative advantage doesn't appear to have as strong an effect on the rate of market penetration.

In trying to distinguish the key factors affecting potential vs. penetration, EPRI suggests that market potential is predominantly influenced by the following:

- the market population and demographic trends
- the needs of the market: customer perceptions, attitudes, and beliefs
- feasibility of the product, which depends on functional characteristics of the product and its economic advantages compared with alternatives.

According to EPRI, the rate of market penetration is predominantly influenced by other factors:

1. marketing effort, such as promotion, advertising, and product positioning
2. product characteristics, such as complexity, compatibility, trialability, and observability
3. characteristics of potential adopters, such as decision-making style, innovativeness, and adoption processes
4. market characteristics, such as macroeconomic conditions, degree of social interaction among potential adopters, and competitive conditions.

Approaches to predicting the diffusion of a new technology general fall under the category of judgmental methods or model-based methods. The judgmental methods share the common trait that they don't require mathematical models or computations; they rely implicitly on the experience and perceptions of the forecaster. On the other hand, model-based methods use well-specified algorithms to process and analyze data. Thus, the model-based methods can provide systematic forecasts of market penetration that are reproducible and amenable to being incorporated into broader integrated models.

Model-based methods can be divided into two major categories: extrapolation models and causal models. Extrapolation methods have the following: 1) naive diffusion process models, 2) moving average, 3) exponential smoothing, 4) Census Bureau X-11, 5) Box-Jenkins, and 6) Multivariate Time Series.

Of the extrapolation methods, the diffusion models represent the principal method for dealing with products that have not yet been introduced. Because this situation generally applies to long-range models, the discussion will be restricted to these models.

The diffusion models assume that the cumulative market penetration follows a characteristic time path (usually in the form of an S-shaped curve). An apt analogy is the spread of contagious disease in a fixed population. Once begun, growth of the disease in the number of infected individuals may follow a stable, predictable path. The time path of the infection in the population depends on the probability of spontaneous infection, the share of infected individuals, and probability of uninfected individuals interacting with individuals already infected. The notion underlying the penetration rate models is that information about the new technology – sufficient to induce its adoption – is similar to an infectious disease (although with a much more positive connotation). This model provides the rationale behind the S-shaped ("logistic") penetration curves that are often observed.

Bass Diffusion Model

Perhaps the dominant type of diffusion model is the mixed-influence model introduced by Bass in the late 1960s. This two-parameter model incorporates parameters that reflect both external and internal influences. The external influence (corresponding to the "spontaneous" infection mentioned above) is exemplified by mass media communication, size of sales force, or other structured channels of information. Spontaneous refers to the adopter not being influenced by previous adopters but by advertising or some other "external change-agent."

In contrast, the internal influence is intended to capture interpersonal communication or word of mouth (i.e., the contagious aspect of the disease analogy above). This also termed the "imitative effect"; the decision to adopt is made only after being influenced by prior adopters.

The basic specification of the Bass model is as follows:

$$dN(t)/dt = [p + q/M\ N(t)]\ [M - N(t)] \qquad (1)$$

where

$N(t)$ = cumulative number of adoptions at time t
M = market potential, a constant
p = the coefficient of innovation or external influence
q = the coefficient of imitation or internal influence.

Equation (1) states that the rate of change in the cumulative number of adopters ($dN(t)/dt$) is proportional to the difference between the market potential M and the number of previous adopters. The proportionality factor $[p + q/M\ N(t)]$ can be interpreted as the probability of adoption at time t. This probability is composed of two components: p is interpreted as the probability of spontaneous adoption. The term $[q/M\ N(t)]$ relates to the probability that adoption will be chosen based on the influence of previous adopters. This probability grows as the number of adopters increases.

To simplify the presentation, Equation (1) can be reoriented in terms of the fraction of the market that is being penetrated rather than the absolute number of adopters. In this case, the market potential can be defined as 1.0. This simplified expression in Equation (2) below now relates to the change in relative cumulative adoptions:

$$dF(t)/dt = [p + qF(t)]\,[1 - F(t)] \tag{2}$$

The number of cumulative adoptions at any time, t, can be solved by specifying an initial condition that the number of adopters at t = 0 is 0. This solution is as follows:

$$F(t) = \frac{1 - \exp[-(p+q)t]}{1 + q/p \exp([-(p+q)]t]} \tag{3}$$

The basic diffusion models therefore separate the issue of market penetration rate from market potential. That is why the model in Equation (3) can be compared across technologies—the percentage change in the total penetration does not depend on the size of the market but only on the parameters p and q.

Estimation Issues

Issues related to the appropriate estimation procedures for the Bass diffusion model spawned a considerable literature up through the mid-1980s. At least four estimation procedures were proposed by various researchers: 1) ordinary least squares (Bass 1969), 2) maximum likelihood estimators (Schmittlein and Mahajan 1982), 3) nonlinear least squares (Srinivasan and Mason 1986) and Jain and Rao (1989), and 4) algebraic estimation (Mahajan and Sharma 1986).

Mahajan, Mason, and Srinivasan (1986) performed a comparative study of estimation procedures using penetration data for seven products. They concluded that the maximum likelihood and nonlinear least squares procedures provided the best predictions of the four procedures considered. Between those two procedures, nonlinear least squares provided slightly better predictive performance and more valid estimates of the standard errors for the parameter estimates.

As preliminary analysis, the authors looked at three variants of nonlinear least squares model. For the first two variants, the focus is on the number of adopters (X) in each period. Taking the differences of Equation (3) above and including a separate parameter to reflects the total number of adopters (m) results in the following for the first variant:

$$X(i) = m\,\frac{[\;1 - \exp(-(p+q)\,t_i\,]}{1 + (q/p)\exp[-(p+q)t_i]} - m\,\frac{[\;1 - \exp(-(p+q)\,t_{i-1}\,]}{1 + (q/p)\exp[-(p+q)t_{i-1}]} + u_i \tag{4}$$

Jain and Rao (1989) suggest that that the formulation in (4) gives the *ex ante* value for X(i) and does not use the *ex post* information on X(1), X(2), …, X(I-1). In the Bass model, the probability that an individual who has not purchased the product up to period t_{i-1} is given by $[F(t_i) - F(t_{i-1})]/((1 - F(t_{i-1})]$. Thus, the number of adopters in the *i*th time interval is as follows:

$$X(i) = (m - N(t_{i-1}))\;[F(t_i) - F(t_{i-1})]/((1 - F(t_{i-1})] + v_i \tag{5}$$

where $N(t_{i-1})$ is the cumulative number of adopters up to time t_{i-1}, v_I is the error term, and cumulative distribution function is given by Equation (3). This *ex post* estimation procedure proposed by Jain and Rao uses the actual number of cumulative adoptions in the estimation, as compared to the *predicted* number in Equation (4). Thus, it is termed the *ex post* estimation in contrast to the *ex ante* estimation.

Mahajan, Mason, and Srinivasan also point out the possibility of estimating the diffusion curve in level rather than differences form (e.g., cumulative sales rather than annual sales). Thus, the cumulative number of adopters is the dependent variable and the specification becomes

$$N(ti) = mF(t) = m \left[\frac{1 - \exp[-(p+q)t]}{[1 + q/p \exp([-(p+q)]t]} \right] + w_i \qquad (6)$$

As Mahajan, Mason, and Srinivasan (1986) indicate, the errors in Equation (6) are likely to be heteroscedastic (i.e., error variance increasing with i) and autocorrelated. Nevertheless, this formulation is somewhat more stable than the differences form and sometimes yields more plausible estimates.

Results

The results of estimating the Bass diffusion model for ten energy-related technologies are described below. The technologies were placed into four separate categories: 1) lighting, 2) HVAC and refrigeration (HVAC/R), 3) envelope, and 4) other. Table 1 summarizes the technologies for which Bass diffusion models were estimated.

Table 1. Summaries of Technologies Analyzed

Technology	Start Year	End Year	Market Definition
Lighting:			
Electronic ballast	1986	1997	Corrected power-factor ballasts
Compact fluorescent	1986	1994	Incandescent, 15-150 watt
T-8 lamps	1986	1994	Fluorescent lamps, >30 watt
HVAC and Refrigeration:			
Electric Heat Pump	1970	1995	Residential furnaces
Flame retention burner	1975	1987	All oil burners
Condensing gas furnace	1982	1997	Gas furnaces
Advanced Compressor	1982	1995	No. of supermarkets
Room Air Conditioners	1949	1961	No. of households
Envelope Technologies:			
Low-E window	1983	1996	Residential windows
Other:			
DOE-2 bldg Model	1984	1994	Commercial buildings designed

In most of the cases, the technology was not assumed to ultimately capture all of the market, as defined in the third column of the table. The maximum market potential was judgmentally determined, on the basis of inspection of the data or from other sources.

Table 2 presents the results of the estimation work. The parameter sets labeled in bold are those judged as the most preferred, based on the reasonableness of the estimates and statistical significance. At this point, estimates based on annual adoptions have been used. The annual adoption rates are expressed as a fraction of the total potential market and the maximum fraction of the total market potential is expressed exogenously. The first and third groups of estimates reflect an effort to allow the data to suggest the maximum market potential (m rather than m^*).

Examining the estimated coefficients indicates that the estimates of the external influence parameter are much more variable than those for the internal influence parameter. One of the lowest values of the internal influence coefficient is found for compact fluorescent lamps, which

Table 2. Diffusion Curve Parameter Results

Product	Annual Sales						Cumulative Sales					
	p	q	m	p	q	m*	p	q	m	p	q	m*
Electronic ballasts	.0054 (0.6)	.6489 (2.5)	.4815 (3.4)	.0138 (1.1)	.3729 (3.3)	0.6	.0037 (2.1)	.7006 7.3)	.4627 (19.5)	.0092 (3.3)	439 9.3)	0.6
Compact Fluorescent				.0075	.071	0.50						
T-8 Lamps				.0041	.326	0.80						
Electric Heat Pump				.0118	0.459	0.23	.0054 (1.6)	.6228 5.9)	.2169 (43.9)	.0112 (2.2)	.4588 (6.3)	.23
Flame retention burner				.0039	0.655	1.0	<.001 (0.3)	1.774 (3.7)	.8143 (23.9)	.0040 (1.1)	.655 (4.6)	1.0
Condensing gas furnace				.070 (1.8)	.071 (0.8)	0.3	.0782 (3.6)	.2082 (1.8)	.238 (14.7)	.0881 (6.1)	.0240 (0.6)	0.3
Room air conditioners				.0072	.423	0.33						
Advanced compressors	.0232 (9.6)	.2788 (11.3)	.9514 (21.3)	0.247 (11.2)	.2483 (22.1)	1.0	.0242 (31.4)	.2633 (20.5)	.9801 (39.8)			
Low-E windows	.0562 (8.2)	.2936 (7.3)	.3663 (18.3)	.0577 (9.6)	.2729 (14.3)	0.37				.0565 (25.0)	.2819 (27.3)	0.37
DOE-2 Building Model	.00001 (0.5)	1.18 (4.8)	.279 (6.4)	.0005	.656	.50						
m* is an assumed value taken from graphical output.												

reflect their extremely slow penetration into the market to date. (In addition to their high initial price, Haddad [1994] suggests that industrial organization, retail incentives, and social convention are additional reasons for the atypically slow adoption of this technology.) On the other extreme is the flame retention oil burner, whose adoption was accelerated by the increase in oil prices during the Iranian revolution in the late 1970s. In spite of these extremes, the simple average internal influence coefficient of 0.38 is the same as the average for 213 technologies as reported by Sultan, Farley, and Lehmann (1990). In that study, the average external influence was 0.03, compared with an average 0.018 for the ten energy-related technologies.

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List of Terms

BTS	Office of Building Technology, State and Community Programs
DOE	U.S. Department of Energy
EPRI	Electric Power Research Institute
PNNL	Pacific Northwest National Laboratory

Appendix D
Methodology

Appendix D
GPRA Metrics Methodology

This appendix describes the calculation methodology used within the Building Energy Savings Estimation Tool (BESET) and the National Energy Modeling System (NEMS) to estimate the energy savings for programs in the following decision units:

- Community Energy Program
- Energy Star Program
- Residential Buildings Integration
- Commercial Buildings Integration
- Equipment, Materials, and Tools.

The programs in the other three decision units, State Energy Program, Weatherization Assistance Program, and Technology Roadmaps and Competitive R&D, were calculated within spreadsheets using the inputs outlined in the main report for these appendixes – *Documentation for FY 2002 BTS GPRA Metrics*.

Because of the number and length of the tables in this appendix, all the tables are shown at the end of the discussion.

Methodology for Whole-Building Programs

This section addresses programs that target the building envelope, a whole-building design approach, or the total building system and that are modeled as improvements to the building envelope. Envelope programs are characterized by a reduction in space conditioning and water heating load from changes in the building system or envelope. The following programs in the U.S. Department of Energy's (DOE's) Office of Building Technology, State and Community Programs (BTS) are characterized by the whole-building approach:

- Rebuild America (in Community Energy Program decision unit)
- Residential Buildings R&D (in Residential Buildings Integration decision unit)
- Commercial Buildings R&D (in Commercial Buildings Integration decision unit)
- Analysis Tools and Design Strategies (in Equipment, Materials, and Tools decision unit).

This section uses the FY 2001 Residential Buildings R&D program to illustrate the calculation methodology. The steps below are involved in calculating the energy savings associated with the Residential Buildings R&D program and are discussed in the next subsections:

- Determine the size of the potential market.
- Determine the number of units affected by the BTS program.
- Determine the base space conditioning and water heating end-use loads.
- Determine the space conditioning and water heating end-use loads after program implementation.
- Calculate the energy savings.

Determine Size of the Potential Market

The Residential Building R&D program targets new residential construction. The size of this potential market is shown in Table D.1 and is part of the baseline assumptions (see Appendix A). Table D.1 shows the new residential building stock, in millions of households, for the north and south regions. The stock of new buildings is defined as those built within the year, not the total new building stock (all buildings built since 2001). The last row of the table represents the cumulative new building stock total (all buildings built since 2001).

Determine Number of Units Affected by the BTS Program

The number of units affected by the BTS program is calculated using the program penetration rates (Table D.2) and the building stock (Table D.1). The penetration rates are applied to the appropriate market segment to compute the number units impacted by the BTS program (see Table D.3). For the new building stock, this figure represents the number of impacted housing units within that year, not the cumulative number. Because energy savings are accumulated over time—a housing unit impacted by the BTS program in 2001 will continue to save energy throughout its life—the number of impacted units must be summed to represent the total number of impacted housing units in the given year (see Table D.4). Therefore, the total number of impacted units listed for single-family houses for 2005 in Table D.3 (.016) represents the number built between 2004 and 2005 that are impacted by the BTS program, while the corresponding number in Table D.4 (.040) represents the number of units impacted since the program was implemented or 2001, whichever is later.

Some envelope programs affect the existing building stock, unlike the Residential Building R&D program. The existing building stock is defined as the total stock in 2001 that survive in each subsequent year. The penetration into that building stock therefore represents the cumulative number of units to that time period, negating the need to accumulate the number of installed units.

Determine Base Space Conditioning and Water Heating End-Use Loads

The end-use loads for heating, cooling, and water heating for new residential buildings are shown in Table D.5 and are part of the baseline assumptions (see Appendix A). The performance improvements for envelope programs are characterized by reductions in the space conditioning and water heating loads. Therefore, the base energy consumption does not have to be explicitly calculated. Instead, the load reduction is applied to the base load to determine the new load; and the resulting difference in loads is used to calculate energy savings.

Determine Space Conditioning and Water Heating End-Use Loads After Program Implementation

The performance inputs for envelope programs are defined in terms of percent load reductions. Table D.6 presents the percent load reductions for the Residential Building R&D program.

The load reductions are applied to the corresponding end-use load segment to determine the building-level load reductions by end use, presented in Table D.7. The building-level load reductions are translated into aggregate load reductions by region by multiplying the

calculated building-level load reductions (in absolute terms, KBtu/sq ft or MMBtu/ household) by cumulative installed units for that region (given in Table D.4). Tables D.8 and D.9 present the regional load reductions by end use.

Calculate Energy Savings

The regional load reductions must be translated into regional energy savings. To do this, baseline assumptions regarding existing equipment efficiencies and existing equipment market shares are used. First, the regional load reductions are divided by the baseline existing equipment efficiencies (listed in Table D.10), which yields potential energy savings by equipment type and end use, as shown in Table D.11.

The potential energy savings assume that each equipment type has 100% of the market, so the actual equipment market shares must then be applied. Table D.12 shows the existing baseline equipment market shares. The market share for each equipment type is multiplied by the potential energy savings calculated in Table D.11 to determine the actual energy savings, as shown in Table D.13.

The savings calculated in Table D.13 are aggregated by fuel type to determine the total delivered electric savings, total primary electric savings (equal to total delivered electricity multiplied by electricity conversion factor that varies by year), total natural gas savings, total oil savings, and total primary savings. Table D.14 presents the energy savings.

Equipment and Standards – General Methodology Using the National Energy Modeling System

Most of the programs in the Equipment, Materials, and Tools decision unit target specific types of equipment within a building or standards directed toward the usage of specific equipment. Equipment programs are characterized by new equipment efficiencies and are compared with "baseline" efficiencies to calculate energy savings. To determine the penetration of the BTS equipment relative to the more conventional equipment, the National Energy Modeling System (NEMS) for the Energy Information Administration's (EIA's) *Annual Energy Outlook* (AEO 2000) has been used as part of the FY 2002 GPRA metrics to estimate the energy savings of various BTS equipment programs.

The NEMS commercial and residential demand modules generate forecasts of energy demand (energy consumption) for the commercial and residential sectors. The commercial demand module generates fuel consumption forecasts for electricity, natural gas, and distillate fuel oil. These forecasts are based on energy prices and macroeconomic variables from the NEMS system, combined with external data sources. The residential model uses energy prices and macroeconomic indicators to generate energy consumption by fuel type and census division in the residential sector. The commercial and residential demand modules are described in the following subsections.

Commercial Demand

This module includes assembly, education, food service, food sales, health care, lodging, mercantile/service, and office buildings. Commercial energy demand within NEMS is calculated in four basic steps. The first step is to forecast commercial sector floorspace. The second step is

to forecast energy services such as space conditioning equipment, lighting, water heating, and refrigeration. The third step is to select specific technologies to meet the demand of energy services. This step involves modeling consumer behavior and capturing the decision between such equipment as incandescent lights and fluorescent lights. The final step involves determining how much energy will be consumed by the equipment chosen to meet the demand for energy services.

This third step is a key element in calculating the estimated energy savings of a given technology promoted by a particular BTS program. Within this step, consumers are assumed to purchase energy-using equipment to meet three types of service demands: services for new buildings, replacement of old equipment that is at the end of its technical life, and replacement of old equipment that is at the end of its economic life (although it still may be technically viable). The NEMS commercial model is coded to allow the use of several possible assumptions about consumer behavior to model this decision process. The assumptions are designed to represent empirically the range of economic factors that most influence the consumer's decision and include the following:

1. Consumer buys the equipment with the minimum life-cycle cost.
2. Consumer buys equipment that uses the same fuel as existing and retiring equipment but minimizes costs across technologies using that fuel.
3. Consumer buys (or keeps) the same technology as the existing and retiring equipment but chooses among different efficiency levels based on minimum life-cycle cost.

The model is designed to choose among a discrete set of technologies that are exogenously characterized by commercial availability, capital costs, operating and maintenance costs, efficiencies, and lifetime. For GPRA metrics, the menu of equipment may be altered to include relevant BTS program equipment, technological innovations, and standards. The NEMS design can accommodate a changing menu of technology choices, recognizing that changes in energy prices and consumer demand may significantly change the set of relevant technologies that the model user wishes to consider.

Residential Demand

The residential sector demand module includes single-family, multifamily, and mobile home dwellings. Residential energy demand is modeled using a sequence of five steps. The first step is to forecast housing stock. The second step is to select the specific technologies to meet the demand for each energy service (e.g. furnaces and heat pumps). The third step is to forecast appliance stocks that are required by each end-use service. The fourth step is to forecast changes in building-shell integrity. Building-shell efficiency in new construction is assumed to improve over the forecast period because of stricter building codes and other efficiency programs and may fluctuate in response to fuel price changes from the base year. The final step is to calculate the energy consumed by the equipment chosen to meet the demand for energy services.

As with the commercial model, the GPRA metrics methodology involves modifying the technology performance and cost inputs to reflect the BTS-developed equipment. The technology and equipment selection simulates the behavior of residential consumers based on the relative importance of life-cycle costs, capital costs, and operating costs of competing technologies within a service. Decisions on new and replacement equipment reflect additional factors beyond the traditional life-cycle cost methodology, including space heating fuel choice and previous

equipment choices. The technology and equipment selection allocates end-use services based on a defined equipment menu of the various technologies and fuels that compete in the market.

Methodology for Specific Energy Star Programs

This section covers the methodological approach to calculating energy savings for the programs related to the following types of equipment:

- water heaters (Energy Star gas and electric water heaters)
- refrigerators (Energy Star refrigerators)
- clothes washers (Energy Star clothes washers)
- air conditioners (Energy Star room air conditioners)
- dishwashers (Energy Star dishwashers).

The modifications to the NEMS input file (RTEKTY) for each appliance with an Energy Star program are described below. The baseline assumptions made by EIA, the changes in the Beta1 coefficients, and the resulting changes in the market shares for the most energy-efficient products are documented. For a few appliances, some changes were made in the baseline assumptions made by EIA; the reasons for these changes are briefly discussed.

Data Input Modifications for Energy Star Refrigerators

Baseline Modifications. EIA uses four separate models to represent the range of energy efficiencies in the refrigerator market. The first three models are conventional top-mount freezer models with a total capacity of 18 cubic feet. The fourth model is a through-the-door model (for water and ice) and does not compete with the first three models. The market share of the through-the-door model is a constant 27% over the forecast horizon. A review of Arthur D. Little's (ADL's) (1998) efficiency and cost forecasts, as well as a recent paper from Oak Ridge National Laboratory (ORNL) (Vineyard and Sand 1998), suggests some changes to EIA's assumptions used in the *AEO 2000* projection are warranted.

As part of the EIA forecast, an assumption is made that the 2001 standard (Model 1) yields no increase in cost. Table D.15 shows the EIA efficiency and cost assumptions. This assumption appears to contradict some of the ADL findings. The ADL performance/cost characteristics information suggests that a 460-kWh/yr unit would have an installed cost of $580 to $700. To be conservative, an installation cost of $600 could be assumed. Because a 478-kWh/yr unit is nearly as efficient as the 460-kWh/yr unit, one would expect it would be only negligibly less expensive. Using this logic, the cost of the 478-kWh/yr unit is assumed to be about $580. These revised assumptions are included in Table D.16.

The ADL report suggests that a 460-kWh/yr model represents a typical model after 2002. A high-efficiency model is specified to consume 400 kWh per year. However, this specification is for a 20-cubic-foot model rather than 18 cubic feet. ADL suggests a cost differential of $100 to $120 between these two models.

The 1998 paper by ORNL's Vineyard and Sand (1998) adds some support to this revision in the cost structure. Vineyard and Sand start with a "1996 model baseline unit" of 20 cubic feet that uses 613 kWh/year. The baseline is already 16% more efficient than the 1993 standard (2.01 kWh/day) resulting from the National Appliance Energy Conservation Act. From this baseline,

Vineyard and Sand focus on two high-efficiency designs. The most aggressive design would reduce energy by 273 kWh/yr at a retail cost increase of about $270. A more cost-effective unit would consume 1.16 kWh/day (423 kWh/yr) at a projected cost increase of $106.

Given this information, the resulting estimated cost increase of $100 between the 460- and 400-kWh/day units appears to be more reasonable (see Table D.16) than EIA's incremental cost of $150. The ORNL baseline unit is less efficient than the 2001 standard and achieves a 30% energy reduction with a little more than a $100 cost increase. This suggests that the 13% efficiency improvement (460 to 400) between models 2 and 3 could be achieved for $100 or less.

Modeling. The two parameters are labeled by EIA as Beta1 and Beta2. Beta1 is used as multiplicative factor with the initial cost of the appliance. Beta2 is used to multiply the annual energy cost. The sum of the two products (i.e., Beta1 * initial cost + Beta2 * operating cost) is used in the logit specification to yield market shares for each technology. The Beta1 and Beta2 coefficients are contained with the cost and efficiency data inputs in the file RTEKTY.

As a rough approximation, the ratio of Beta1/Beta2 can be interpreted as the consumer discount rate for the specific appliance. In the residential NEMS module, the Beta1 and Beta2 coefficients vary among appliances, as do the resulting discount rates. For example, the implied discount rates for refrigerators are 16%. On the other hand, the discount rate is estimated to be over 80% for electric water heaters.

The EIA used the parameters -0.0229 (Beta1) and -0.1207 (Beta2) to reflect the discount rate used by consumers in evaluating various refrigerators are. This translates into approximately a 19% discount rate (Beta1/Beta2).

For modeling purposes, the focus of the Energy Star program is assumed to increase the market share of the 400-kWh/yr refrigerator. This unit is about 16% more efficient than a unit meeting the most recent national standard. To generate a larger market share for this model, the Beta1 coefficient was changed to -0.0055.

The NEMS residential model does not automatically produce an output table that displays the shares of individual appliances with different efficiencies. These shares are computed within the model for each building type (single family, multifamily, and mobile home) and by the nine census divisions. The NEMS-BTS model was modified to display the shares for the single-family market segment for three separate years: 2005, 2010, and 2020. The results from NEMS for 2005 and 2010 are shown in Table D.17.

Energy Star Clothes Washers

Modeling the energy savings clothes washers is complex because energy savings can be achieved by reducing the consumption of the motor, reducing hot water use, or reducing dryer use. The most efficient new technology is the horizontal-axis design, which achieves the bulk of its energy savings by the reduction in hot water use.

The residential NEMS input file (RTEKTY) includes a column of factors that relates to hot water. The (unit less) factors can be used to adjust the hot water load associated with clothes washers and dishwashers. In preliminary model runs, the values associated with clothes washers appeared to be too low compared with the information supplied by Lawrence Berkeley National Laboratory (LBNL) in support of an efficiency standard for clothes washers. These

factors were adjusted from 0.67 to 2.00 for vertical-axis machines. The coefficient for the horizontal-axis machine was increased from 0.24 to 0.40. The value for the vertical axis machine was estimated by making runs of the model with and without *any* hot water and observing the resulting energy consumption. The LBNL analysis suggests that 80% to 90% of the energy consumption of clothes washers is attributable to water heating. Table D.18 shows the original and revised NEMS inputs for clothes washers.

For the Energy Star program, the discount rate was adjusted to achieve larger shares for the more efficient vertical axis machine as well as the horizontal axis machine. In the baseline run, horizontal axis machines had zero market shares (thus, the model is not consistent with current sales information that shows that these machines are being sold in limited numbers.) The goal of the GPRA exercise was to increase the market share of these machines to 8% to 10% of the market. This result was roughly achieved by reducing the Beta1 coefficient in the model from 0.03811 to 0.0101. Table D.19 shows the results of the NEMS model runs for clothes washers.

Energy Star Hot Water Heaters

Separate sets of NEMS runs were made for electric water heaters and gas water heaters to model the effects of Energy Star programs.

Electric Water Heater. The key NEMS used by EIA for the *AEO 2000* are shown in Table D.20. With these assumed costs, the model projects a zero share for heat pump water heaters.

The Energy Star program was assumed to target high-efficiency electric water heaters whose efficiencies exceed 0.9. As shown in Table D.20, two such units are shown, with efficiencies of 0.95 and 0.96. By 2005, the installed cost of the high-efficiency unit (at the 0.96 efficiency level) is assumed to fall to $475.

The logit parameters in the NEMS model related to the choice of electric water heaters are –0.01619 (Beta1) and –0.01952 (Beta2), implying a discount rate of about 83%. For the GPRA estimate for the Energy Star program, the Beta1 coefficient was reduced to 0.0082, implying a discount rate of about 43%. This change resulted in an increase in the market shares of the (assumed) Energy Star products of roughly 11 percentage points. The specific results are shown in Table D.21.

Gas Water Heaters. The key NEMS inputs used by EIA for the AEO 2000 are shown in Table D.22. With these assumed costs, the model projects a zero share for the (near) condensing units that have efficiencies greater than 0.8.

The Energy Star program was assumed to target high-efficiency gas water heaters whose efficiencies are 0.6 or higher. As shown in Table D.20, two such units are shown, with efficiencies of 0.6 and 0.63. By 2005, the installed cost of the high-efficiency unit (at the 0.60 efficiency level) is assumed to fall from $400 to $375.

The logit parameters in the NEMS model related to the choice of gas water heaters are -0.05393 (Beta1) and -0.1136 (Beta2), implying a discount rate of about 47%. For the GPRA estimate for the Energy Star program, the Beta1 coefficient was reduced to 0.0323, implying a discount rate of about 28%. This change resulted in an increase in the market shares of the (assumed) Energy Star products of a little more than 12 percentage points. The specific results are shown in Table D.23.

Energy Star Room Air Conditioners

For the year 2005, EIA assumes that efficiencies of room air conditioners will range from a low of 2.83 SEER (seasonal energy efficiency ratio) to a high of 3.52 SEER. In the *AEO 2000* input file for the residential NEMS module, two models were at the low end of this range (SEER = 2.83, SEER = 2.93), while two models were at the high end of the range. To achieve a more realistic set of choices, a model with an intermediate efficiency of 3.11 was added and the unit at the 2.93 (SEER) level was dropped. The increase in cost to go from a SEER of 2.83 to 2.93 was assumed to be $30. Table D.24 shows both the original NEMS input data and the revised data.

The high-efficiency units with an energy-efficiency ratio (EER) of >3.4 were assumed to fall under the Energy Star program. In the base case, the combined market share for the units with SEERs of 3.43 and 3.52 were less than 1%. The split between the lowest efficiency unit (SEER = 2.83) and the intermediate efficiency unit (SEER = 3.11) was generally about 75%/25% in favor of the lowest efficiency model.

The logit parameters in the NEMS model related to the choice of room air conditioners are -0.017 (Beta1) and -0.12 (Beta2), implying a discount rate of over 100%. For the GPRA estimate for the Energy Star program, the Beta1 coefficient was reduced to 0.007, implying a discount rate of about 58%. This change resulted in an increase in the market shares of the (assumed) Energy Star products of a little more than 12 percentage points. (In addition, the market share of the model with the intermediate efficiency of 3.11 increased from approximately 25% to 35%, also contributing to estimated energy savings). Table D.25 shows the specific results for the high-efficiency model.

Energy Star Dishwashers

The NEMS baseline (*AEO 2000*) data input for the year 2005 shows three dishwashers, with energy factors 0.46, 0.59, and 0.71. The associated costs of these units are shown in Table D.26. Given the cost structure and logit choice parameters, the model suggests that consumers select slightly more than 6% of dishwashers with the 0.59 energy factor and virtually none of the very high efficiency units.

The logit parameters in the NEMS model related to the choice of dishwashers are -0.02738 (Beta1) and -0.02413 (Beta2), implying a discount rate of over 100%. For the GPRA estimate for the Energy Star program, the Beta1 coefficient was reduced to 0.01338, implying a discount rate of about 55%. This change resulted in an increase in the market share of the intermediate efficiency unit (energy factor = 0.59) of about 15 percentage points (to over 20%). The market share of the very high efficiency unit increases to a little more than 3%. The specific results for the two high-efficiency models are shown in Table D.27.

NEMS Modeling of Emerging Technologies

NEMS was used to estimate the energy savings associated with the products being developed under BTS's Emerging Technologies program. The NEMS residential model used was modified to represent two technologies under this program: 1) heat pump water heater and 2) condensing gas water heater. The high-efficiency rooftop air conditioner program was modeled in the NEMS commercial model.

The modifications to the NEMS input files (RTEKTY.txt for residential, KTECH.wk1 for commercial) for each type of equipment in the Emerging Technologies program are described below. The baseline assumptions made by EIA, the cost and performance attributes of the BTS-sponsored technologies, and the resulting market shares for these most energy-efficient products are documented. For a few appliances, some changes were made in EIA's baseline assumptions; the reasons for these changes are briefly discussed.

General Methodology

For the FY 2002 GPRA effort, the water heater technologies funded by the Emerging Technologies program were modeled only in the residential model. The residential model uses a logit specification to estimate the market shares of specific technologies for a given type of appliance. For each appliance, two parameters generally influence how consumers trade off the initial purchase cost versus the annual operating cost of the appliance. The annual operating cost of course depends on the energy efficiency of each technology (or "model") and the price of energy.

Data Input Modifications for Specific Appliance and Emerging Technology Programs

The modifications to the NEMS input file (RTEKTY) for each appliance being developed under the Appliance and Emerging Technologies program are described below. The baseline assumptions made by EIA, the performance and cost assumptions for the BTS-sponsored technologies, and the resulting changes in the market shares for the most energy-efficient products are documented. For a few appliances, some changes were made in EIA's baseline assumptions; the reasons for these changes are briefly discussed.

Heat Pump Water Heater. The input file used for the *AEO 2000* includes several categories of heat pump water heaters, two of which are shown in Table D.28. Inexplicably, the lower-cost unit is assumed to have a higher efficiency. With the discount rates used in the *AEO 2000* for electric water heaters, only a very small number of the $1,000 unit are predicted to be sold (and none of the higher-cost unit). A more moderately priced heat pump unit is assumed to become available in 2005, with a cost of $900 and an energy factor of 2.0. By 2015, the cost falls to $800 and the energy factor increases to 2.2.

The original *AEO 2000* input file does not reflect the pending water heater standards that are scheduled to take effect in 2004. Two modifications were made to crudely account for these standards: 1) technology 1 was assumed to be unavailable after 2003, and 2) the efficiency for technology 2 was changed to 0.89 with an unchanged cost. The new standard calls for a 50-gallon unit (as assumed in the table) to have an energy factor between 0.89 and 0.90. These modifications are shown at the top of Table D.28.

The Appliance and Emerging Technologies program is assumed to lead to a more rapid commercialization of a moderately priced heat pump water heater, first available in 2004. But the principal impact of the program is to achieve a lower cost than the unit assumed to be introduced in 2005 in the AEO base case. As shown in Table D.28, the units are assumed initially to have energy efficiency rating of 2.0 and a cost of $700 (installed). By 2010, further development will yield a unit with slightly higher efficiency (2.10) at a lower cost ($650). By 2015, further improvements lead to an efficiency of 2.2 at a cost of $600. (Note that the *AEO 2000* input assumptions already include a heat pump water heater but at a substantially higher cost). (For modeling, the units introduced in the Emerging Technologies program replace the

$900 and $800 units that are part of the AEO base case, and therefore the base case units are not shown in Table D.28).

One issue related to assessing benefits of this technology with the NEMS model is the appropriate discount rate to use. The logit parameters in the NEMS model related to the choice of electric water heaters are -0.01619 (Beta1) and -0.01952 (Beta2), implying a discount rate of about 83%. At this discount rate, the high initial cost of the heat pump water heater, even with its much higher efficiency, discourages most consumers from choosing this technology. The NEMS results shown in Column 2 of Table D.29 show that the market share does not quite reach 5%, even with the third-generation unit assumed in the analysis. (Note: The market shares in this discussion pertain only to electric water heaters.)

A more realistic overall assessment of the program is obtained by assuming that the ongoing Energy Star program for water heaters provides impetus for increased market acceptance of the heat pump water heater. In this scenario, the changes in the discount rates assumed for Energy Star program are combined with the introduction of the (lower-cost) heat pump water heater. As for the GPRA estimate for the Energy Star program, the Beta1 coefficient in the NEMS model was reduced to 0.0072, implying a discount rate of about 37%. As shown in Table D.29, the lower discount rates generate much higher penetrations of the heat pump water heater, ultimately reaching nearly 25% of sales by 2010. (While Table D.29 displays the shares for only new homes, the shares for the replacement market are similar).

The program's energy savings (not shown here) are thus calculated as the difference between NEMS model runs that 1) include the heat pump waters assumed in the AEO base case and 2) substitute the lower-cost units assumed to stem from the Emerging Technologies program. In both runs, the adjustments to the discount rate (via the Beta1 coefficient) are the same as those used in evaluating the Energy Star program for water heaters. The Energy Star program is assumed to promote greater adoption of both conventional resistance units with energy factors of 0.95 or higher as well as heat pump water heaters. In essence, the program's savings are calculated as the difference between an Energy Star program with and without the units developed under the Emerging Technologies program. (The program summary contains further discussion of the savings from the Energy Star program without these lower-cost heat pumps.) Under Energy Star the market share of the $900 heat pump unit in 2010 is 0.046 compared with a 0.239 share of the $700 unit, as shown in Table D.29.)

Finally, the assumption of an ongoing Energy Star program raises the question of whether that program should receive some of the credit for energy savings brought about by this technology. No clear methodology exists for decomposing the benefits between applied R&D program and market conditioning activities. Clearly, without the existence of the more efficient technology, Energy Star is limited in the impact that it can make toward reducing actual energy use. If such an attribution must be made for the GPRA process, 70% of the savings are proposed to be assigned to the Emerging Technologies program and 30% to Energy Star.

Condensing Gas Water Heater. The original *AEO 2000* input file does not reflect the pending water heater standards that are scheduled to take effect in 2004. To account for these standards in the gas water heater market, the technologies with energy factors <0.60 (0.54 and 0.58) were specified to be unavailable after 2003. These modifications are shown in the top two lines of Table D.30.

EIA includes a high-efficiency condensing gas water heater in its menu of technology choices for the *AEO 2000*. As Table D.30 shows, these units have very high costs. Not surprisingly, the model yields negligible market shares for this technology.

The Emerging Technologies program is assumed to lead to the commercialization of a moderately priced condensing gas water heater, first available in 2003. As Table D.30 shows, the units are assumed initially to have an energy efficiency rating of 0.8 and cost $550 (installed). By 2010, further development is assumed to yield a unit with slightly lower cost ($525).

As with the heat pump water heater, an issue related to the assessment of benefits with the NEMS model is the appropriate discount rate to employ. The logit parameters in the NEMS model related to the choice of gas water heaters are -0.05393 (Beta1) and -0.1136 (Beta2), implying a discount rate of about 47%. At this discount rate, the higher initial cost of the BTS-sponsored condensing gas water heater, even with its much higher efficiency, discourages most consumers from choosing this technology. The NEMS results shown in Column 2 of Table D.31 show that the market share only reaches about 1%, even with the lower-cost second-generation unit assumed in the analysis.

As with the heat pump water heater, a more realistic overall assessment of the program is obtained by assuming that the ongoing Energy Star program for water heaters provides impetus for increased market acceptance of the condensing gas water heater. In this scenario, the changes in the discount rates assumed for Energy Star program are combined with the introduction of the (lower-cost) condensing gas water heater. As for the GPRA estimate for the Energy Star program, the Beta1 coefficient in the NEMS model was reduced to -0.03593, implying a discount rate of about 32%. As shown in Table D.31, the lower discount rates generate much higher penetrations of the condensing water heater, ultimately reaching nearly 10% of sales by 2010. The inputs in the *AEO 2001* assume the introduction of a high efficiency *non*condensing unit in 2015. This assumption is the principal explanation for why the share of the condensing unit drops between 2010 and 2020. (While Table D.31 displays the shares for only new homes, the shares for the replacement market are similar).

Again, the assumption of an ongoing Energy Star program raises the question of whether that program should receive some of the credit for energy savings brought about by this technology. No clear methodology exists for separating the benefits between applied R&D program and market conditioning activities. Without the more efficient technology, Energy Star is limited in the impact it can make toward reducing actual energy use. If such an attribution must be made for the GPRA process, 70% of the savings again is proposed to be assigned to the Emerging Technologies program and 30% to Energy Star.

High-Efficiency Rooftop Air Conditioner. The rooftop air conditioner program uses competitive procurements of large numbers of units to stimulate the production of high-efficiency equipment. Its immediate goal is to get high-efficiency equipment installed in buildings owned by the federal government other state and local agencies. In the long term, however, a key outcome of the program is to provide incentives for manufacturers to reduce the cost of this equipment to all potential and private sector buyers.

With this long-term goal in mind, the assumed costs of high efficiency roof top air conditioners were adjusted in the NEMS commercial model to reflect the principal influence of this program. In NEMS, two air conditioners were specified in the rooftop category—a baseline unit (EER = 8.5)

and a high-efficiency unit (EER= 11.6). No subgroups were distinguished by capacity (e.g., 65 to 135 kBtu/h vs. 135 to 240 kBtu/h).

An alternative technology spreadsheet was developed to model the rooftop initiative in the Emerging Technologies. (In most recent version of NEMS, the technology cost and performance inputs are in a spreadsheet). In this spreadsheet, the user can adjust the *incremental* cost between baseline unit and the high-efficiency unit.

For the GPRA analysis, the incremental cost was reduced by 40%. Given the proportion of the market assumed in the NEMS to display high discount rates in the selection of equipment, this cost reduction was necessary to yield a 9% penetration of the high-efficiency unit in 2005. The penetration rate falls to 6% in 2010 possibly the result of a couple of factors: 1) greater efficiency of the baseline unit or 2) lower energy costs. As this point, the exact reasons for this behavior have not yet been investigated. By 2020, the proportion of the total stock using the high-efficiency unit is about 5%.

GPRA Envelope Calculations Using NEMS

The general approach for GPRA envelope calculations using NEMS was to simulate the effect of an envelope technology using the Facility Energy Decision System (FEDS)[1] model for many different building types, sizes, vintages, and locations. The heating and cooling loads were calculated for each building with and without the envelope technology being evaluated. The changes in the heating and cooling loads were then used to modify the heating and cooling envelope factors used in NEMS. These factors were input as a vector for each building type and census region; these vectors captured both the thermal impact and the expected market penetration by year. Market penetration estimates were based on input from the DOE Program Manager or their representatives.

FEDS Modeling

To estimate the national impact of introducing a new envelope technology, the impact of that technology must be accurately captured within the buildings where it is likely to be employed. For each technology, the impact was simulated in 3,960 commercial buildings and 1,188 residential buildings representing all combinations of building type, size, vintage, and location (see Table D.32).

Aggregating FEDS Results for NEMS

Because NEMS only models one of each building type in each of the nine census regions, the FEDS results needed to be aggregated for input into NEMS.

City Weights. The cities shown in Table D.32 were selected for the FEDS analysis because the weather is characteristic of the climate in the different portions of the census regions. Because NEMS operates on a census region bases, weighted averages of the FEDS results for individual weather cities were produced to represent the loads within a census region. Table D.33 shows the weights given to each city for each census region.

[1] Pacific Northwest National Laboratory (1998).

Floor Area Weights. The fraction of floor space within each size category for each commercial building type was determined using data from Commercial Buildings Energy Consumption Survey (CBECS)[2] and is shown in Table D.34.

Table D.35 shows the fraction of floor space within each size category for each residential building type (single family, mobile homes, and multifamily). The data for single-family and mobile homes was determined using data from Residential Energy Consumption Survey (RECS)[3],[4] and the data for multifamily homes was determined using data from RECS and apartment stock data from the National Multi-Housing Council.[5]

Vintage Weights. All vintages were given equal weighting.

Market Penetration. The DOE program manager, or representative, provided market penetration point estimates. For example, the Program Manager estimated the market penetration to be 15% in 2020 for quick-fill walls in new single-story buildings. Given that 41.8%[6] of commercial buildings are single story, this resulted in a market penetration rate of 6.3%.

These estimates were then used in the previously developed and documented market penetration model (see Appendix C) to estimate the market penetration by year. Pertinent data for the market penetration estimates are provided in Table D.36.

Baseline Assumptions

Consistent with the NEMS model, the heating and cooling envelope factors were assumed to be decreasing over time. These changes account for technological improvements over time that would occur without the DOE program. The baseline envelope factors in NEMS are modified annually to account for the technological improvements, and the modifiers are calculated using the following equation with 1995 being the base year:

$$Baseline\,Modifier_{new\ buildings} = 0.94^{\left(\frac{CurrentYear-1995}{25}\right)}$$

and

$$Baseline\,Modifier_{existing\ buildings} = 0.96^{\left(\frac{CurrentYear-1995}{25}\right)}$$

The program benefits are in addition to the baseline modifier.

[2] 1995 CBECS, Table 9. Where no data were available, expert judgment was used.
[3] 1997 RECS, Table HC1-4b, single-family.
[4] 1997 RECS, Table HC1-4b, five or more units.
[5] http://www.nmhc.org/research/default.html.
[6] 1995 CBECS, Table 9.

Special Considerations

For the electrochromic windows program, 30% of the lighting energy used in commercial buildings is also assumed to be saved. These savings occur at the same rate as the penetration of the electrochromic technology.

Output

The output for each technology has nine columns of output containing the following information.

- census division
- building type
- year
- total heating envelope factor adjustment for new buildings
- total cooling envelope factor adjustment for new buildings
- total heating envelope factor adjustment for existing buildings
- total cooling envelope factor adjustment for existing buildings
- lighting load adjustment for new buildings
- lighting load adjustment for existing buildings.

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List of Terms

ADL	Arthur D. Little
AEO	Annual Energy Outlook (report)
AFUE	annual fuel utilization efficiency

BTS	Office of Building Technology, State and Community Programs
CBECS	Commercial Buildings Energy Consumption Survey
COP	coefficient of performance
DOE	U.S. Department of Energy
EER	energy efficiency ratio
EIA	Energy Information Administration
FEDS	Facility Energy Decision System
GPRA	Government Performance and Results Act of 1993
LBNL	Lawrence Berkeley National Laboratory
NEMS	National Energy Modeling System
ORNL	Oak Ridge National Laboratory
RECS	Residential Energy Consumption Survey
SEER	seasonal energy efficiency ratio

Table D.1. Size of the Residential Building Market

Building Type	Vintage	Region	Millions of Households					
			2001	2005	2010	2015	2020	2030
Single Family	New	North	.52	.52	.53	.52	.51	.50
Single Family	New	South	.52	.52	.53	.52	.51	.50
Mobile Homes	New	North	.14	.14	.13	.12	.1	.09
Mobile Homes	New	South	.17	.17	.16	.15	.13	.11
Multifamily	New	North	.18	.18	.22	.22	.19	.18
Multifamily	New	South	.18	.18	.22	.22	.19	.18
Residential	New	All	1.71	1.71	1.79	1.75	1.63	1.56
Residential	New	Cumulative	1.71	8.56	17.52	26.28	34.49	49.99

Table D.2. Potential Penetration Rates for New Construction

Building Type	Vintage	Region	% of New Construction in Period					
			2001	2005	2010	2015	2020	2030
Single Family	New	North	.3	3.1	11.6	22.1	27	28.6
Single Family	New	South	.3	3.1	11.6	22.1	27	28.6
Mobile Homes	New	North	.1	1	3.8	7.3	8.9	9.4
Mobile Homes	New	South	.1	1	3.8	7.3	8.9	9.4
Multifamily	New	North	.1	.7	2.6	4.9	5.9	6.3
Multifamily	New	South	.1	.7	2.6	4.9	5.9	6.3

Table D.3. Number of Units Impacted by the BTS

Building Type	Vintage	Region	Millions of Households					
			2001	2005	2010	2015	2020	2030
Single Family	New	North	.002	.016	.061	.115	.138	.143
Single Family	New	South	.002	.016	.061	.115	.138	.143
Mobile Homes	New	North	.0001	.001	.005	.009	.009	.008
Mobile Homes	New	South	.0002	.002	.006	.01	.012	.010
Multifamily	New	North	.0002	.001	.006	.011	.011	.011
Multifamily	New	South	.0002	.001	.006	.011	.011	.011

Table D.4. Cumulative Impacted of Household Units

Building Type	Vintage	Millions of Households						
		Region	2001	2005	2010	2015	2020	2030
Single Family	New	North	.002	.040	.245	.720	1.67	2.78
Single Family	New	South	.002	.040	.245	.720	1.67	2.78
Mobile Homes	New	North	.0001	.004	.020	.056	.100	.183
Mobile Homes	New	South	.0002	.004	.025	.069	.122	.224
Multifamily	New	North	.0002	.003	.022	.066	.120	.230
Multifamily	New	South	.0002	.003	.022	.066	.120	.230

D.5. End-Use Loads for Heating, Cooling, and Water Heating for New Residential Buildings (MBtu/household/yr)

Building Type	Vintage	Region	2001	2005	2010	2015	2020	2030
End Use: Space Heating								
Single Family	New	North	42.24	42.24	42.24	42.24	42.24	42.24
Single Family	New	South	12.98	12.98	12.98	12.98	12.98	12.98
Mobile Homes	New	North	42.24	42.24	42.24	42.24	42.24	42.24
Mobile Homes	New	South	12.98	12.98	12.98	12.98	12.98	12.98
Multifamily	New	North	42.24	42.24	42.24	42.24	42.24	42.24
Multifamily	New	South	12.98	12.98	12.98	12.98	12.98	12.98
End Use: Space Cooling								
Single Family	New	North	8.62	8.62	8.62	8.62	8.62	8.62
Single Family	New	South	13.58	13.58	13.58	13.58	13.58	13.58
Mobile Homes	New	North	8.62	8.62	8.62	8.62	8.62	8.62
Mobile Homes	New	South	13.58	13.58	13.58	13.58	13.58	13.58
Multifamily	New	North	8.62	8.62	8.62	8.62	8.62	8.62
Multifamily	New	South	13.58	13.58	13.58	13.58	13.58	13.58
End Use: Water Heating								
Single Family	New	North	12.94	12.94	12.94	12.94	12.94	12.94
Single Family	New	South	12.94	12.94	12.94	12.94	12.94	12.94
Mobile Homes	New	North	12.94	12.94	12.94	12.94	12.94	12.94
Mobile Homes	New	South	12.94	12.94	12.94	12.94	12.94	12.94
Multifamily	New	North	12.94	12.94	12.94	12.94	12.94	12.94
Multifamily	New	South	12.94	12.94	12.94	12.94	12.94	12.94

Table D.6. Percent Load Reductions for the Residential Building R&D Program for Space Heating and Cooling and Water Heating

Building Type	Vintage	Region	% Load Reduction					
			2001	2005	2010	2015	2020	2030
Single Family	New	North	38	50	50	50	50	50
Single Family	New	South	38	50	50	50	50	50
Mobile Homes	New	North	38	50	50	50	50	50
Mobile Homes	New	South	38	50	50	50	50	50
Multifamily	New	North	38	50	50	50	50	50
Multifamily	New	South	38	50	50	50	50	50

Table D.7. Building-Level Load Reductions by End Use (MMBtu/household/yr)

Building Type	Vintage	Region	2001	2005	2010	2015	2020	2030
End Use: Space Heating								
Single Family	New	North	16.05	21.12	21.12	21.12	21.12	21.12
Single Family	New	South	4.93	2.465	2.465	2.465	2.465	2.465
Mobile Homes	New	North	16.05	21.12	21.12	21.12	21.12	21.12
Mobile Homes	New	South	4.93	2.465	2.465	2.465	2.465	2.465
Multifamily	New	North	16.05	21.12	21.12	21.12	21.12	21.12
Multifamily	New	South	4.93	2.465	2.465	2.465	2.465	2.465
End Use: Space Cooling								
Single Family	New	North	3.27	4.31	4.31	4.31	4.31	4.31
Single Family	New	South	5.16	6.79	6.79	6.79	6.79	6.79
Mobile Homes	New	North	3.27	4.31	4.31	4.31	4.31	4.31
Mobile Homes	New	South	5.16	6.79	6.79	6.79	6.79	6.79
Multifamily	New	North	3.27	4.31	4.31	4.31	4.31	4.31
Multifamily	New	South	5.16	6.79	6.79	6.79	6.79	6.79
End Use: Water Heating								
Single Family	New	North	4.92	6.47	6.47	6.47	6.47	6.47
Single Family	New	South	4.92	6.47	6.47	6.47	6.47	6.47
Mobile Homes	New	North	4.92	6.47	6.47	6.47	6.47	6.47
Mobile Homes	New	South	4.92	6.47	6.47	6.47	6.47	6.47
Multifamily	New	North	4.92	6.47	6.47	6.47	6.47	6.47
Multifamily	New	South	4.92	6.47	6.47	6.47	6.47	6.47

Table D.8. Regional Load Reductions by End Use (TBtu/yr)

Building Type	Vintage	Region	2001	2005	2010	2015	2020	2030
End Use: Space Heating								
Single Family	New	North	.03	.84	5.17	15.21	35.27	58.71
Single Family	New	South	.01	.10	.60	1.77	4.11	6.85
Mobile Homes	New	North	.002	.08	.42	1.18	2.11	3.86
Mobile Homes	New	South	.001	.01	.06	.17	.30	.55
Multifamily	New	North	.003	.06	.46	1.39	2.53	4.86
Multifamily	New	South	.001	.007	.05	.16	.30	.57
End Use: Space Cooling								
Single Family	New	North	.01	.17	1.06	3.10	7.20	11.98
Single Family	New	South	.01	.27	1.66	4.89	11.34	18.88
Mobile Homes	New	North	.0003	.02	.09	.24	.43	.79
Mobile Homes	New	South	.001	.03	.17	.47	.83	1.52
Multifamily	New	North	.0007	.01	.09	.28	.52	.99
Multifamily	New	South	.001	.02	.15	.45	.81	1.56
End Use: Water Heating								
Single Family	New	North	.01	.26	1.59	4.66	10.8	17.99
Single Family	New	South	.01	.26	1.59	4.66	10.8	17.99
Mobile Homes	New	North	.001	.03	.13	.36	.65	1.18
Mobile Homes	New	South	.001	.03	.16	.45	.79	1.15
Multifamily	New	North	.001	.02	.14	.43	.78	1.49
Multifamily	New	South	.001	.02	.14	.43	.78	1.49

Table D.9. Cumulative Regional Load Reductions (TBtu/yr)

Building Type	Vintage	Region	2001	2005	2010	2015	2020	2030
End Use: Space Heating								
Single Family	New	North	0.025	0.798	5.127	15.154	28.822	58.601
Single Family	New	South	0.010	0.319	2.051	6.063	11.532	23.446
Mobile Homes	New	North	0.002	0.070	0.423	1.181	2.107	3.871
Mobile Homes	New	South	0.001	0.034	0.207	0.577	1.030	1.893
Multifamily	New	North	0.003	0.066	0.459	1.393	2.540	4.839
Multifamily	New	South	0.001	0.026	0.184	0.557	1.016	1.936
End Use: Space Cooling								
Single Family	New	North	0.005	0.163	1.046	3.093	5.882	11.959
Single Family	New	South	0.008	0.257	1.648	4.872	9.266	18.840
Mobile Homes	New	North	0.000	0.014	0.086	0.241	0.430	0.790
Mobile Homes	New	South	0.001	0.028	0.166	0.464	0.828	1.521
Multifamily	New	North	0.001	0.013	0.094	0.284	0.518	0.987
Multifamily	New	South	0.001	0.021	0.148	0.448	0.817	1.556
End Use: Water Heating								
Single Family	New	North	0.008	0.245	1.571	4.642	8.830	17.952
Single Family	New	South	0.008	0.245	1.571	4.642	8.830	17.952
Mobile Homes	New	North	0.001	0.022	0.130	0.362	0.646	1.186
Mobile Homes	New	South	0.001	0.026	0.158	0.442	0.789	1.449
Multifamily	New	North	0.001	0.020	0.141	0.427	0.778	1.482
Multifamily	New	South	0.001	0.020	0.141	0.427	0.778	1.482

Table D.10 Existing Equipment Efficiencies

End Use	Fuel Type	Equipment Type	Units*	2001	2005	2010	2015	2020	2030
Space Heat	Elec	Heat Pump	COP	1.99	1.99	1.99	1.99	1.99	1.99
Space Heat	Elec	Forced Air	AFUE	1	1	1	1	1	1
Space Heat	Gas	Furnace	AFUE	.78	.78	.78	.78	.78	.78
Space Heat	Oil	Furnace	AFUE	.78	.78	.78	.78	.78	.78
Space Heat	Gas	High-Efficiency Furnace	AFUE	.92	.92	.92	.92	.92	.92
Space Heat	Gas	Heat Pump	COP	1.4	1.4	1.4	1.4	1.4	1.4
Space Cool	Elec	Heat Pump	COP	2.93	2.93	2.93	2.93	2.93	2.93
Space Cool	Elec	Central Air Conditioning	COP	3.02	3.02	3.02	3.02	3.02	3.02
Space Cool	Elec	Room Air	COP	2.64	2.64	2.64	2.64	2.64	2.64
Space Cool	Gas	Heat Pump	COP	.95	.95	.95	.95	.95	.95
Water Heat	Elec	Storage	Effic	.89	.93	.93	.93	.93	.93
Water Heat	Gas	Storage	Effic	.55	.62	.62	.62	.62	.62
Water Heat	Oil	Storage	Effic	.55	.55	.56	.56	.56	.56
*COP = coefficient of performance; AFUE = annual fuel utilization efficiency; Effic = efficiency.									

Table D.11. Potential Energy Savings (TBtu/yr)

Building Type	Region	2001	2005	2010	2015	2020	2030
Space Heating: Electric Heat Pump							
Single Family	North	0.013	0.401	2.576	7.615	14.484	29.448
Single Family	South	0.005	0.161	1.031	3.047	5.795	11.782
Mobile Homes	North	0.001	0.035	0.213	0.593	1.059	1.945
Mobile Homes	South	0.001	0.017	0.104	0.290	0.518	0.951
Multifamily	North	0.001	0.033	0.231	0.700	1.276	2.432
Multifamily	South	0.001	0.013	0.092	0.280	0.511	0.973
Space Heating: Electric Forced Air							
Single Family	North	0.02	0.80	5.13	15.15	28.82	58.60
Single Family	South	0.01	0.32	2.05	6.06	11.53	23.45
Mobile Homes	North	0.00	0.07	0.42	1.18	2.11	3.87
Mobile Homes	South	0.00	0.03	0.21	0.58	1.03	1.89
Multifamily	North	0.00	0.07	0.46	1.39	2.54	4.84
Multifamily	South	0.00	0.03	0.18	0.56	1.02	1.94
Space Heating: Gas Furnace							
Single Family	North	0.03	1.02	6.57	19.43	36.95	75.13
Single Family	South	0.01	0.41	2.63	7.77	14.78	30.06
Mobile Homes	North	0.00	0.09	0.54	1.51	2.70	4.96
Mobile Homes	South	0.00	0.04	0.27	0.74	1.32	2.43
Multifamily	North	0.00	0.08	0.59	1.79	3.26	6.20
Multifamily	South	0.00	0.03	0.24	0.71	1.30	2.48
Space Heating: Oil Furnace							
Single Family	North	0.03	1.02	6.57	19.43	36.95	75.13
Single Family	South	0.01	0.41	2.63	7.77	14.78	30.06
Mobile Homes	North	0.00	0.09	0.54	1.51	2.70	4.96
Mobile Homes	South	0.00	0.04	0.27	0.74	1.32	2.43
Multifamily	North	0.00	0.08	0.59	1.79	3.26	6.20
Multifamily	South	0.00	0.03	0.24	0.71	1.30	2.48
Space Heating: High-Efficiency Gas Furnace							
Single Family	North	0.03	0.87	5.57	16.47	31.33	63.70
Single Family	South	0.01	0.35	2.23	6.59	12.53	25.48
Mobile Homes	North	0.00	0.08	0.46	1.28	2.29	4.21
Mobile Homes	South	0.00	0.04	0.22	0.63	1.12	2.06
Multifamily	North	0.00	0.07	0.50	1.51	2.76	5.26
Multifamily	South	0.00	0.03	0.20	0.61	1.10	2.10
Space Heating: Gas Heat Pump							
Single Family	North	0.02	0.57	3.66	10.82	20.59	41.86
Single Family	South	0.01	0.23	1.47	4.33	8.24	16.75
Mobile Homes	North	0.00	0.05	0.30	0.84	1.51	2.77
Mobile Homes	South	0.00	0.02	0.15	0.41	0.74	1.35
Multifamily	North	0.00	0.05	0.33	0.99	1.81	3.46
Multifamily	South	0.00	0.02	0.13	0.40	0.73	1.38
Space Cooling: Heat Pump							
Single Family	North	0.00	0.06	0.36	1.06	2.01	4.08
Single Family	South	0.00	0.09	0.56	1.66	3.16	6.43
Mobile Homes	North	0.00	0.00	0.03	0.08	0.15	0.27
Mobile Homes	South	0.00	0.01	0.06	0.16	0.28	0.52
Multifamily	North	0.00	0.00	0.03	0.10	0.18	0.34
Multifamily	South	0.00	0.01	0.05	0.15	0.28	0.53
Space Cooling: Central Air Conditioning							
Single Family	North	0.00	0.04	0.27	0.79	1.51	3.07
Single Family	South	0.00	0.07	0.42	1.25	2.38	4.83

Building Type	Region	2001	2005	2010	2015	2020	2030
Mobile Homes	North	0.00	0.00	0.02	0.06	0.11	0.20
Mobile Homes	South	0.00	0.01	0.04	0.12	0.21	0.39
Multifamily	North	0.00	0.00	0.02	0.07	0.13	0.25
Multifamily	South	0.00	0.01	0.04	0.11	0.21	0.40
Space Cooling: Room Air							
Single Family	North	0.00	0.06	0.40	1.17	2.23	4.53
Single Family	South	0.00	0.10	0.62	1.85	3.51	7.14
Mobile Homes	North	0.00	0.01	0.03	0.09	0.16	0.30
Mobile Homes	South	0.00	0.01	0.06	0.18	0.31	0.58
Multifamily	North	0.00	0.01	0.04	0.11	0.20	0.37
Multifamily	South	0.00	0.01	0.06	0.17	0.31	0.59
Space Cooling: Gas Heat Pump							
Single Family	North	0.01	0.17	1.10	3.26	6.19	12.59
Single Family	South	0.01	0.27	1.73	5.13	9.75	19.83
Mobile Homes	North	0.00	0.02	0.09	0.25	0.45	0.83
Mobile Homes	South	0.00	0.03	0.18	0.49	0.87	1.60
Multifamily	North	0.00	0.01	0.10	0.30	0.55	1.04
Multifamily	South	0.00	0.02	0.16	0.47	0.86	1.64
Water Heat: Electric							
Single Family	North	0.01	0.26	1.69	4.99	9.49	19.30
Single Family	South	0.01	0.26	1.69	4.99	9.49	19.30
Mobile Homes	North	0.00	0.02	0.14	0.39	0.69	1.28
Mobile Homes	South	0.00	0.03	0.17	0.48	0.85	1.56
Multifamily	North	0.00	0.02	0.15	0.46	0.84	1.59
Multifamily	South	0.00	0.02	0.15	0.46	0.84	1.59
Water Heat: Gas							
Single Family	North	0.01	0.39	2.53	7.49	14.24	28.96
Single Family	South	0.01	0.39	2.53	7.49	14.24	28.96
Mobile Homes	North	0.00	0.03	0.21	0.58	1.04	1.91
Mobile Homes	South	0.00	0.04	0.26	0.71	1.27	2.34
Multifamily	North	0.00	0.03	0.23	0.69	1.26	2.39
Multifamily	South	0.00	0.03	0.23	0.69	1.26	2.39
Water Heat: Oil							
Single Family	North	0.01	0.44	2.80	8.29	15.77	32.06
Single Family	South	0.01	0.44	2.80	8.29	15.77	32.06
Mobile Homes	North	0.00	0.04	0.23	0.65	1.15	2.12
Mobile Homes	South	0.00	0.05	0.28	0.79	1.41	2.59
Multifamily	North	0.00	0.04	0.25	0.76	1.39	2.65
Multifamily	South	0.00	0.04	0.25	0.76	1.39	2.65

Table D.12. Equipment Market Shares (%)

Building Type	Region	2001	2005	2010	2015	2020	2030
Space Heating: Electric Heat Pump							
Single Family	North	13	14	15	16	17	17
Single Family	South	27	28	29	30	32	32
Mobile Homes	North	13	14	15	16	17	17
Mobile Homes	South	27	28	29	30	32	32
Multifamily	North	13	14	15	16	17	17
Multifamily	South	27	28	29	30	32	32
Space Heating: Electric Forced Air							
Single Family	North	7	8	9	10	11	11
Single Family	South	12	13	15	17	19	19
Mobile Homes	North	7	8	9	10	11	11
Mobile Homes	South	12	13	15	17	19	19
Multifamily	North	7	8	9	10	11	11
Multifamily	South	12	13	15	17	19	19
Space Heating: Gas Furnace							
Single Family	North	56	52	47	41	36	36
Single Family	South	47	43	38	32	27	27
Mobile Homes	North	56	52	47	41	36	36
Mobile Homes	South	47	43	38	32	27	27
Multifamily	North	56	52	47	41	36	36
Multifamily	South	47	43	38	32	27	27
Space Heating: Oil Furnace							
Single Family	North	3	3	3	3	3	3
Single Family	South	1	1	1	1	1	1
Mobile Homes	North	3	3	3	3	3	3
Mobile Homes	South	1	1	1	1	1	1
Multifamily	North	3	3	3	3	3	3
Multifamily	South	1	1	1	1	1	1
Space Heating: High-Efficiency Gas Furnace							
Single Family	North	15	17	20	23	26	26
Single Family	South	12	14	16	18	20	20
Mobile Homes	North	15	17	20	23	26	26
Mobile Homes	South	12	14	16	18	20	20
Multifamily	North	15	17	20	23	26	26
Multifamily	South	12	14	16	18	20	20
Space Heating: Gas Heat Pump							
Single Family	North	2	2	2	2	2	2
Single Family	South	1	0	0	0	0	0
Mobile Homes	North	2	2	2	2	2	2
Mobile Homes	South	1	0	0	0	0	0
Multifamily	North	2	2	2	2	2	2
Multifamily	South	1	0	0	0	0	0
Space Cooling: Heat Pump							
Single Family	North	13	14	15	16	17	17
Single Family	South	27	28	29	30	32	32
Mobile Homes	North	13	14	15	16	17	17
Mobile Homes	South	27	28	29	30	32	32
Multifamily	North	13	14	15	16	17	17
Multifamily	South	27	28	29	30	32	32
Space Cooling: Central Air Conditioning							
Single Family	North	56	55	54	53	52	52
Single Family	South	58	57	55	54	53	53

Building Type	Region	2001	2005	2010	2015	2020	2030
Mobile Homes	North	56	55	54	53	52	52
Mobile Homes	South	58	57	55	54	53	53
Multifamily	North	56	55	54	53	52	52
Multifamily	South	58	57	55	54	53	53
Space Cooling: Room Air							
Single Family	North	3	3	2	2	2	2
Single Family	South	1	1	1	1	1	1
Mobile Homes	North	3	3	2	2	2	2
Mobile Homes	South	1	1	1	1	1	1
Multifamily	North	3	3	2	2	2	2
Multifamily	South	1	1	1	1	1	1
Space Cooling: Gas Heat Pump							
Single Family	North	2	2	2	2	2	2
Single Family	South	1	0	0	0	0	0
Mobile Homes	North	2	2	2	2	2	2
Mobile Homes	South	1	0	0	0	0	0
Multifamily	North	2	2	2	2	2	2
Multifamily	South	1	0	0	0	0	0
Water Heat: Electric							
Single Family	North	23	23	22	22	22	22
Single Family	South	23	23	22	22	22	22
Mobile Homes	North	23	23	22	22	22	22
Mobile Homes	South	23	23	22	22	22	22
Multifamily	North	23	23	22	22	22	22
Multifamily	South	23	23	22	22	22	22
Water Heat: Gas							
Single Family	North	73	73	73	74	74	74
Single Family	South	73	73	73	74	74	74
Mobile Homes	North	73	73	73	74	74	74
Mobile Homes	South	73	73	73	74	74	74
Multifamily	North	73	73	73	74	74	74
Multifamily	South	73	73	73	74	74	74
Water Heat: Oil							
Single Family	North	5	5	4	4	4	4
Single Family	South	5	5	4	4	4	4
Mobile Homes	North	5	5	4	4	4	4
Mobile Homes	South	5	5	4	4	4	4
Multifamily	North	5	5	4	4	4	4
Multifamily	South	5	5	4	4	4	4

Table D.13. Actual Energy Savings (TBtu/yr)

Building Type	Region	2001	2005	2010	2015	2020	2030
Space Heating: Electric Heat Pump							
Single Family	North	0.00	0.06	0.39	1.22	2.46	5.01
Single Family	South	0.00	0.04	0.30	0.91	1.85	3.77
Mobile Homes	North	0.00	0.00	0.03	0.09	0.18	0.33
Mobile Homes	South	0.00	0.00	0.03	0.09	0.17	0.30
Multifamily	North	0.00	0.00	0.03	0.11	0.22	0.41
Multifamily	South	0.00	0.00	0.03	0.08	0.16	0.31
Space Heating: Electric Forced Air							
Single Family	North	0.00	0.06	0.46	1.52	3.17	6.45
Single Family	South	0.00	0.04	0.31	1.03	2.19	4.45
Mobile Homes	North	0.00	0.01	0.04	0.12	0.23	0.43
Mobile Homes	South	0.00	0.00	0.03	0.10	0.20	0.36
Multifamily	North	0.00	0.01	0.04	0.14	0.28	0.53
Multifamily	South	0.00	0.00	0.03	0.09	0.19	0.37
Space Heating: Gas Furnace							
Single Family	North	0.02	0.53	3.09	7.97	13.30	27.05
Single Family	South	0.01	0.18	1.00	2.49	3.99	8.12
Mobile Homes	North	0.00	0.05	0.25	0.62	0.97	1.79
Mobile Homes	South	0.00	0.02	0.10	0.24	0.36	0.66
Multifamily	North	0.00	0.04	0.28	0.73	1.17	2.23
Multifamily	South	0.00	0.01	0.09	0.23	0.35	0.67
Space Heating: Oil Furnace							
Single Family	North	0.00	0.03	0.20	0.58	1.11	2.25
Single Family	South	0.00	0.00	0.03	0.08	0.15	0.30
Mobile Homes	North	0.00	0.00	0.02	0.05	0.08	0.15
Mobile Homes	South	0.00	0.00	0.00	0.01	0.01	0.02
Multifamily	North	0.00	0.00	0.02	0.05	0.10	0.19
Multifamily	South	0.00	0.00	0.00	0.01	0.01	0.02
Space Heating: High-Efficiency Gas Furnace							
Single Family	North	0.00	0.15	1.11	3.79	8.15	16.56
Single Family	South	0.00	0.05	0.36	1.19	2.51	5.10
Mobile Homes	North	0.00	0.01	0.09	0.30	0.60	1.09
Mobile Homes	South	0.00	0.01	0.04	0.11	0.22	0.41
Multifamily	North	0.00	0.01	0.10	0.35	0.72	1.37
Multifamily	South	0.00	0.00	0.03	0.11	0.22	0.42
Space Heating: Gas Heat Pump							
Single Family	North	0.00	0.01	0.07	0.22	0.41	0.84
Single Family	South	0.00	0.00	0.00	0.00	0.00	0.00
Mobile Homes	North	0.00	0.00	0.01	0.02	0.03	0.06
Mobile Homes	South	0.00	0.00	0.00	0.00	0.00	0.00
Multifamily	North	0.00	0.00	0.01	0.02	0.04	0.07
Multifamily	South	0.00	0.00	0.00	0.00	0.00	0.00
Space Cooling: Heat Pump							
Single Family	North	0.00	0.01	0.05	0.17	0.34	0.69
Single Family	South	0.00	0.02	0.16	0.50	1.01	2.06
Mobile Homes	North	0.00	0.00	0.00	0.01	0.02	0.05
Mobile Homes	South	0.00	0.00	0.02	0.05	0.09	0.17
Multifamily	North	0.00	0.00	0.00	0.02	0.03	0.06
Multifamily	South	0.00	0.00	0.01	0.05	0.09	0.17
Space Cooling: Central Air Conditioning							
Single Family	North	0.00	0.02	0.14	0.42	0.78	1.59
Single Family	South	0.00	0.04	0.23	0.67	1.26	2.56

Building Type	Region	2001	2005	2010	2015	2020	2030
Mobile Homes	North	0.00	0.00	0.01	0.03	0.06	0.11
Mobile Homes	South	0.00	0.00	0.02	0.06	0.11	0.21
Multifamily	North	0.00	0.00	0.01	0.04	0.07	0.13
Multifamily	South	0.00	0.00	0.02	0.06	0.11	0.21
Space Cooling: Room Air							
Single Family	North	0.00	0.00	0.01	0.02	0.04	0.09
Single Family	South	0.00	0.00	0.01	0.02	0.04	0.07
Mobile Homes	North	0.00	0.00	0.00	0.00	0.00	0.01
Mobile Homes	South	0.00	0.00	0.00	0.00	0.00	0.01
Multifamily	North	0.00	0.00	0.00	0.00	0.00	0.01
Multifamily	South	0.00	0.00	0.00	0.00	0.00	0.01
Space Cooling: Gas Heat Pump							
Single Family	North	0.00	0.00	0.02	0.07	0.12	0.25
Single Family	South	0.00	0.00	0.00	0.00	0.00	0.00
Mobile Homes	North	0.00	0.00	0.00	0.01	0.01	0.02
Mobile Homes	South	0.00	0.00	0.00	0.00	0.00	0.00
Multifamily	North	0.00	0.00	0.00	0.01	0.01	0.02
Multifamily	South	0.00	0.00	0.00	0.00	0.00	0.00
Water Heat: Electric							
Single Family	North	0.00	0.06	0.37	1.10	2.09	4.25
Single Family	South	0.00	0.06	0.37	1.10	2.09	4.25
Mobile Homes	North	0.00	0.01	0.03	0.09	0.15	0.28
Mobile Homes	South	0.00	0.01	0.04	0.10	0.19	0.34
Multifamily	North	0.00	0.00	0.03	0.10	0.18	0.35
Multifamily	South	0.00	0.00	0.03	0.10	0.18	0.35
Water Heat: Gas							
Single Family	North	0.01	0.29	1.85	5.54	10.54	21.43
Single Family	South	0.01	0.29	1.85	5.54	10.54	21.43
Mobile Homes	North	0.00	0.03	0.15	0.43	0.77	1.42
Mobile Homes	South	0.00	0.03	0.19	0.53	0.94	1.73
Multifamily	North	0.00	0.02	0.17	0.51	0.93	1.77
Multifamily	South	0.00	0.02	0.17	0.51	0.93	1.77
Water Heat: Oil							
Single Family	North	0.00	0.02	0.11	0.33	0.63	1.28
Single Family	South	0.00	0.02	0.11	0.33	0.63	1.28
Mobile Homes	North	0.00	0.00	0.01	0.03	0.05	0.08
Mobile Homes	South	0.00	0.00	0.01	0.03	0.06	0.10
Multifamily	North	0.00	0.00	0.01	0.03	0.06	0.11
Multifamily	South	0.00	0.00	0.01	0.03	0.06	0.11

Table D.14. Energy Savings by Fuel Type (TBtu/yr)

Fuel Type	2001	2005	2010	2015	2020	2030
Delivered Electricity	0.0	0.5	3.3	10.2	20.3	40.7
Primary Electricity	0.0	1.3	8.2	24.4	45.2	90.8
Natural Gas	0.1	1.8	11.0	31.5	57.8	116.2
Oil	0.0	0.1	0.5	1.6	2.9	5.9
Total Primary	0.1	3.2	19.7	57.5	106.0	213.0

Table D.15. Refrigerator Efficiency and Costs: *AEO 2000*

Model	Initial Year	Ending Year	Annual Consumption (kWh)	Installed Cost (1998$)	Retail Cost (1998$)
1	1997	2001	690	530	480
1	2002	2020	478	530	480
2	1997	2001	660	550	500
2	2002	2020	460	550	500
3	1993	2001	518	850	800
3	2002	2020	460	550	500
3	2005	2020	400	700	650
4	1993	2001	843	1313.8	1313.8
4	2002	2020	577	1313.8	1313.8

Table D.16. Refrigerator Efficiency and Costs: GPRA Baseline

Model	Initial Year	Ending Year	Annual Consumption (kWh)	Installed Cost (1998 $)	Retail Cost (1998 $)
1	1997	2001	690	530	480
1	2002	2020	478	580	480
2	1997	2001	660	550	500
2	2002	2020	460	600	550
3	1997	2001	518	850	800
3	2002	2020	460	600	550
3	2005	2020	400	700	650
4	1997	2001	843	1313.8	1313.8
4	2002	2020	577	1313.8	1313.8

Table D.17. Energy Star Program – Refrigerators (market share of 400-kWh/yr units)

Census Division	2005		2010	
	Baseline	Energy Star	Baseline	Energy Star
1	.0427	.2068	.0426	.2064
2	.0409	.2003	.0400	.1971
3	.0337	.1727	.0329	.1698
4	.0326	.1687	.0327	.1689
5	.0342	.1748	.0341	.1744
6	.0330	.1702	.0329	.1696
7	.0329	.1698	.0322	.1668
8	.0355	.1801	.0356	.1805
9	.0354	.1793	.0357	.1807

Table D.18. Original and Revised NEMS Inputs for Clothes Washers

Technology	Start Yr	End Yr	Water Coeff.	Energy Factor	Installed Cost	Type
Original NEMS Inputs						
1	1997	2020	.67	2.71	$490	V-Axis
2	1997	2004	.67	3.88	$645	V-Axis
3	2005	2020	.67	3.88	$590	V-Axis
4	1997	2020	.24	4.45	$800	H-Axis
5	2005	2020	.24	5.27	$800	H-Axis
6	2015	2020	.24	5.44	$800	H-Axis
Revised NEMS Inputs						
1	1997	2020	2	2.71	$490	V-Axis
2	1997	2004	2	3.88	$645	V-Axis
3	2005	2020	2	3.88	$590	V-Axis
4	1997	2020	.4	4.45	$800	H-Axis
5	2005	2020	.4	5.27	$800	H-Axis
6	2015	2020	.4	5.44	$800	H-Axis

Table D.19. NEMS-Generated Shares of Clothes Washers by Technology

Census Division	2005		2010	
	Baseline	Energy Star	Baseline	Energy Star
1	.0000	.0927	.0000	.0923
2	.0000	.0904	.0000	.0900
3	.0000	.0814	.0000	.0804
4	.0000	.0794	.0000	.0794
5	.0000	.0813	.0000	.0812
6	.0000	.0799	.0000	.0797
7	.0000	.0801	.0000	.0791
8	.0000	.0831	.0000	.0833
9	.0000	.0826	.0000	.0830

Notes: Results shown are for new housing units; replacement shares are generally within 0.5% of values shown here.

Table D.20. Key NEMS Inputs for Electric Water Heaters (*AEO 2000*)

Technology	Start Yr	End Yr	Energy Factor	Installed Cost	Type
1	1997	2020	.86	$350	Resistance
2	1997	2020	.88	$350	Resistance
3	1997	2020	.95	$575	Resistance
4	1997	2020	2.60	$1,025	Heat Pump
5	1997	2020	2.00	$2,600	Heat Pump
6	2005	2020	.89	$350	Resistance
7	2005	2020	.96	$475	Resistance
8	2005	2020	2.00	$900	Heat Pump
9	2015	2020	.90	$400	Resistance
10	2015	2020	.96	$425	Resistance
11	2015	2020	2.20	$800	Heat Pump

Table D.21. NEMS Results for Energy Star Electric Water Heaters (national market shares for new single-family homes)

	2005		2010	
Efficiency Level	Baseline	Energy Star	Baseline	Energy Star
0.95	0.011	0.054	0.011	0.054
0.96	0.056	0.128	0.056	0.127
Total	0.0670	0.1820	0.0670	0.1810
Note: Results shown are for new, single-family housing units; replacement shares are generally within 2% of the values shown here.				

Table D.22. Key NEMS Inputs for Gas Water Heaters

Technology	Start Yr	End Yr	Energy Factor	Installed Cost	Type
1	1997	2020	.54	$340	Non-Condensing
2	1997	2020	.58	$370	Non-Condensing
3	1997	2004	.6	$400	Non-Condensing
4	2005	2020	.6	$375	Non-Condensing
5	1997	2020	.86	$2360	Non-Condensing
6	2005	2014	.86	$2000	Condensing
7	2015	2020	.86	$1800	Condensing
8	2005	2014	.63	$450	Condensing
9	2015	2020	.63	$425	Non-Condensing
10	2015	2020	.7	$500	Non-Condensing

Table D.23. NEMS Results for Energy Star Gas Water Heaters (national market shares for new, single-family homes)

Efficiency Level	2005		2010	
	Baseline	Energy Star	Baseline	Energy Star
0.60	0.307	0.387	0.315	0.384
0.63	0.011	0.068	0.011	0.066
Total	0.318	0.455	0.326	0.450

Table D.24. NEMS Input Parameters for Room Air Conditioners

Technology	Start Year	End Year	SEER	Installed Cost
AEO 2000 and GPRA Baseline				
1	1997	2000	2.55	$450
2	2001	2020	2.83	$450
3	1997	2004	2.93	$500
4	2005	2020	2.93	$490
5	1997	2020	3.43	$760
6	2005	2020	3.43	$760
7	2015	2020	3.22	$600
Revised NEMS Inputs for Room Air Conditioners				
1	1997	2000	2.55	$450
2	2001	2020	2.83	$450
3	1997	2004	3.11	$530
4	2005	2020	3.11	$520
5	1997	2020	3.43	$760
6	2005	2020	3.52	$760
7	2015	2020	3.22	$600

Table D.25. NEMS Results for Energy Star Room Air Conditioners (market shares for new, single-family homes)

	2005		2010	
Census Division	Baseline	Energy Star	Baseline	Energy Star
1	.0083	.1301	.0083	.1299
2	.0085	.1323	.0085	.1321
3	.0085	.1319	.0084	.1314
4	.0084	.1314	.0084	.1312
5	.0091	.1396	.0091	.1395
6	.0091	.1402	.0091	.1398
7	.0101	.1522	.0099	.1501
8	.0085	.1327	.0085	.1327
9	.0084	.1314	.0084	.1317

Table D.26. Key NEMS Data Inputs for Dishwashers

Technology	Start Year	End Year	Water Co-efficiency	Energy Factor	Installed Cost
1	1997	2020	.80	.46	$350
2	1997	2004	.80	.59	$500
3	2005	2020	.80	.59	$450
4	1997	2004	.78	.71	$700
5	2005	2014	.78	.71	$600
6	2015	2020	.78	.71	$500
7	2015	2020	.80	.60	$400

Table D.27. Energy Star Program Dishwashers (estimated market shares for high-efficiency dishwashers)

Census Division	2005				2010			
	Baseline		Energy Star		Baseline		Energy Star	
	EF=.59	EF=.71	EF=.59	EF=.71	EF=.59	EF=.71	EF=.59	EF=.71
1	.0683	.0012	.2219	.0322	.0682	.0012	.2217	.0321
2	.0678	.0012	.2207	.0318	.0677	.0012	.2204	.0317
3	.0659	.0011	.2157	.0305	.0656	.0011	.2151	.0304
4	.0654	.0011	.2146	.0302	.0654	.0011	.2145	.0304
5	.0658	.0011	.2156	.0305	30654	.0011	.2145	.0304
6	.0655	.0011	.2148	.0303	.0658	.0011	.2156	.0305
7	.0656	.0011	.2150	.0303	.0653	.0011	.2144	.0302
8	.0662	.0011	.2166	.0308	.0663	.0012	.2168	.0308
9	.0661	.0011	.2164	.0307	.0663	.0012	.2169	.0308

Table D.28. Key NEMS Inputs for Electric Water Heaters –

Technology	Start Year	End Year	Energy Factor	Installed Cost	Type
1	1197	2003	0.86	$350	Resistance
2	1997	2003	0.88	$350	Resistance
2a	2004	2020	0.89	$350	Resistance
3	1997	2020	0.95	$575	Resistance
4	1997	2020	2.60	$1,025	Heat Pump
5	1997	2020	2.00	$2,600	Heat Pump
6	1997	2020	0.90	$360	Resistance
7	2005	2020	0.96	$475	Resistance
8	2004	2009	2.00	$700	Heat Pump*
8a	2010	2014	2.10	$650	Heat Pump*
9	2015	2020	0.90	$400	Resistance
10	2015	2020	0.96	$425	Resistance
11	2015	2020	2.20	$600	Heat Pump*
* Emerging Technologies program.					

Table D.29. NEMS Results for Emerging Technologies Program's Heat Pump Water Heaters (national market shares for new single-family homes)

Year	Market Share: AEO 2000 Discount Rate	Market Share: Adjusted Discount Rate (Energy Star)
2004	0.024	0.040
2005	0.012	0.031
2006	0.012	0.050
2007	0.012	0.077
2008	0.012	0.116
2010	0.028	0.239
2015	0.047	0.241
2020	0.048	0.243

Table D.30. Key NEMS Inputs for Gas Water Heaters

Technology	Start Yr	End Yr	Energy Factor	Installed Cost	Type
1	1997	2003	0.54	$340	Non-condensing
2	1997	2003	0.58	$370	Non-condensing
3	1997	2004	0.60	$400	Non-condensing
4	2005	2020	0.60	$375	Non-condensing
5	1997	2020	0.86	$2,360	Condensing
6	2005	2014	0.86	$2,000	Condensing
7	2015	2020	0.86	$1,800	Condensing
8	2005	2014	0.63	$450	Non-condensing
9	2015	2020	0.63	$425	Non-condensing
10	2015	2020	0.70	$500	Non-condensing
11	2005	2009	0.80	$550	Condensing--ET Pgm
12	2010	2020	0.8	$525	Condensing--ET Pgm

Table D.31. NEMS Results for Energy Star Gas Water Heaters (national market shares for new single-family homes)

Year	Market Share: AEO 2000 Discount Rate	Market Share: Adjusted Discount Rate
2005	0.003	0.009
2006	0.003	0.015
2007	0.003	0.024
2008	0.003	0.038
2010	0.011	0.129
2015	0.009	0.100
2020	0.010	0.106

Table D.32. Building Simulation Parameters

Building Type	Building Size (ft^2)	Vintage (Year Built)	Location
Assembly	4000	1940	Denver, Colorado
Education	7500	1953	Detroit, Michigan
Food Sales	17500	1967	Fresno, California
Food Service	37500	1976	Knoxville, Tennessee
Healthcare	75000	1983	Los Angeles, California
Lodging	125000	2000	Minneapolis, Minnesota
Mercantile and Service			Phoenix, Arizona
Office			Providence, Rhode Island
Warehouse			Seattle, Washington
Other Commercial Buildings			Shreveport, Louisiana
			Tampa, Florida
Single Family	600		
Mobile Home	800		
	1300		
	1800		
	2200		
	3000*		
Multifamily	14309		
	19079		
	31003		
	42927		
	52466		
	71545		
* Note that single family and mobile homes are represented by the 600 to 3000 single-family range.			

D.33. Weights Given to Each City for Each Census Region (%)

City	New England	Mid Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
Denver	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.0	2.2
Detroit	0.0	0.0	99.3	60.0	0.0	0.0	0.0	0.0	0.0
Fresno	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3
Knoxville	0.0	0.0	0.0	0.0	50.7	67.4	13.4	0.0	0.0
Los Angeles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.2
Minneapolis	0.0	0.0	0.7	40.0	0.0	0.0	0.0	0.0	0.0
Phoenix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	0.0
Providence	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Seattle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2
Shreveport	0.0	0.0	0.0	0.0	17.7	32.6	80.6	0.0	0.0
Tampa	0.0	0.0	0.0	0.0	31.6	0.0	6.0	0.0	0.0

Table D.34. Fraction of Floor Space In Each Size Category for Each Commercial Building Type

Building Type	Floor Space					
	4,000	7,500	17,500	37,500	75,000	125,000
Assembly	7.9	19.9	23.8	12.3	12.6	23.5
Education	3.2	5.2	13.5	23.6	22.6	31.8
Food Sales	36.4	6.4	31.8	19.1	5.1	1.3
Food Service	40.7	28.8	24.4	5.2	0.6	0.3
Healthcare	6.5	6.5	10.4	7.5	5.5	63.6
Lodging	4.1	7.4	20.7	14.2	16.9	36.7
Mercantile and Service	14.5	17.3	23.1	9.3	10.0	25.7
Large Office	0.0	0.0	0.0	0.0	27.5	72.5
Small Office	21.7	18.9	32.7	26.7	0.0	0.0
Other Buildings	10.8	12.8	19.7	13.0	13.5	30.1
Warehouse	9.5	11.7	18.0	13.7	13.5	33.5

Table D.35. Fraction of Floor Space in Each Size Category for Each Residential Type (%)

Building Type	Floor Space					
	600	800	1300	1800	2200	3000
Single Family	2.8	14.0	37.0	21.2	11.3	13.7
Mobile Home	15.7	43.8	31.6	7.2	2.2	0.7
	Floor Space					
	14,309	19,079	31,003	42,927	52,466	71, 545
Multifamily	25.4	49.3	17.9	2.4	0.7	0.2

Table D.36. Market Penetration Estimates

Program	Sector	Vintage	1st Year of Pen.	Penetration in Yr (%)			External Param.	Internal Param.
				2005	2020	2030		
Superwindows	Residential	Existing	2003	1.5	33.0	43.2	0.008	0.2435
Superwindows	Residential	New	2003	3.0	65.0	85.0	0.008	0.2435
Electrochromic Windows	Commercial	Existing	2001	1.8	17.2	43.2	0.0022	0.111
Electrochromic Windows	Commercial	New	2001	2.0	20.0	50.0	0.0022	0.111
R30-30 roof	Commercial	Existing	2010	0.0	15.3	30.2	0.01	0.3
R30-30 roof	Commercial	New	2010	0.0	21.5	42.2	0.01	0.3
Quick Fill Wall	Commercial	Existing	2004	0.0	0.0	0.0	0.01	0.3
Quick Fill Wall	Commercial	New	2004	0.2	6.3	7.2	0.01	0.3
Quick Fill Wall	Residential	Existing	2004	0.0	0.0	0.0	0.01	0.3
Quick Fill Wall	Residential	New	2004	0.3	10.0	11.5	0.01	0.3