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Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios

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Preface

The analysis in this report was undertaken at the request of Senators James M. Jeffords (I-VT) and Joseph I. Lieberman (D-CT), subsequent to the report *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide*, published by the Energy Information Administration (EIA) in December 2000. The analysis in the December 2000 report was expanded in the report *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard*, published by EIA in July 2001. Senators Jeffords and Lieberman requested that EIA consider the impacts of technology improvements and other market-based opportunities on the costs of emissions reductions, as noted in the letter in Appendix A.

This study analyzes the costs and impacts of a set of emissions control limits for electricity generators under four different technology cases. Limits are defined for sulfur dioxide, nitrogen oxides, mercury, and carbon dioxide emissions by 2007 and are the same for each case. The limits are analyzed using the reference case and the high technology case assumptions for end-use demand, supply, and generation technologies in EIA's *Annual Energy Outlook 2001*, published in December 2000, and the moderate and advanced policy cases from *Scenarios for a Clean Energy Future* (*CEF*), a publication of an interlaboratory working group, published in November 2000. The projections in this report were produced using the National Energy Modeling System (NEMS), an energy-economy model of U.S. energy markets designed, developed, and maintained by EIA, which is used each year to provide the projections in EIA's *Annual Energy Outlook*. The energy market results are provided in Appendix C for the reference and advanced technology cases and in Appendix D for the cases based on *CEF*.

The legislation that established EIA in 1977 vested the organization with an element of statutory independence. EIA does not take a position on policy questions. It is the responsibility of EIA to provide timely, high-quality information and to perform objective, credible analyses in support of the deliberations of both public and private decisionmakers. This report does not purport to represent the official position of the U.S. Department of Energy or the Administration.

Within its Independent Expert Review Program, EIA arranged for leading experts in the field of energy and economic analysis to review an earlier version of this report. All comments from the reviewers either have been incorporated or were thoroughly considered for incorporation. As is always the case when peer reviews are undertaken, not all the reviewers may be in agreement with all the methodology, inputs, and conclusions of the final report. The contents of the report are solely the responsibility of EIA. The assistance of the following reviewers is gratefully acknowledged:

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The projections in the reference case in this report are not statements of what will happen but of what might happen, given the assumptions and methodologies used. The reference case projections are business-as-usual trend forecasts, given known technology, technological and demographic trends, and current laws and regulations. Thus, they provide a policy-neutral reference case that can be used to analyze policy initiatives. EIA does not propose, advocate, or speculate on future legislative and regulatory changes. All laws are assumed to remain as currently enacted; however, the impacts of emerging regulatory changes, when defined, are reflected.

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Highlights

This analysis responds to a request by Senators James M. Jeffords (I-VT) and Joseph I. Lieberman (D-CT) to analyze the potential impacts of limits on four emissions from electricity generators, sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and mercury (Hg). Using 2002 as a start date for emissions reductions, the request specifies that by 2007 NO_x emissions from electricity generators are assumed to be reduced to 75 percent below 1997 levels, SO_2 emissions to 75 percent below the full implementation of the Phase II requirements under Title IV of the Clean Air Act Amendments of 1990 (CAAA90), Hg emissions to 90 percent below 1999 levels, and CO_2 emissions to 1990 levels. It is assumed that these emissions limits are applied to all electricity generators, excluding cogenerators, which produce both electricity and useful thermal output.

The impacts of these assumed limits are analyzed against four different cases with varying levels of energy demand: the reference case from the *Annual Energy Outlook 2001* (*AEO2001*), published in December 2000; an advanced technology case combining the high technology assumptions for end-use demand, supply, and generating technologies from *AEO2001*; and cases incorporating the moderate and advanced policies from *Scenarios for a Clean Energy Future* (*CEF*), a November 2000 publication from an interlaboratory working group. The policies in the *CEF* analysis included fiscal incentives, regulations, and increased research and development funding for advanced technologies. The advanced *CEF* case also included a domestic CO_2 trading system for all energy markets that was assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent, which would be announced in 2002 and implemented in 2005.

The cases include all energy laws and regulations in effect as of July 1, 2000, including the NO_x and SO_2 regulations established in the CAAA90, plus the new appliance efficiency standards announced in January 2001 as modified by the current Administration. The analysis was conducted using the Energy Information Administration's (EIA) National Energy Modeling System. Key results are summarized below.

Cases without Emissions Limits

- The *AEO2001* reference case includes continuing development of energy-consuming and producing technologies, consistent with historic trends in research and development funding. The advanced technology assumptions in *AEO2001* are based on more optimistic technology development throughout the energy system, consistent with more aggressive research and development programs. The costs to achieve these technology improvements are not quantified because there is no analysis showing that funding levels for research and development can be tied directly to the successful development of new technologies.

- The moderate and advanced cases in *CEF* included a number of policies to encourage the development and adoption of technologies that are more energy-efficient and with lower emissions. However, the success of these programs was based on assumed changes in consumer behavior that are not consistent with historic behavior patterns, result from research and development funding increases that have not occurred, and voluntary and information programs for which there is no analytical basis for evaluating the impacts. Also, some of the assumed *CEF* policies required legislative or regulatory actions that may not be enacted at all or may be enacted at later dates than assumed in *CEF*.

- Future technology development cannot be known with certainty, and even the technology improvements assumed in the reference case are likely, but not certain. The more rapid technology development assumed in the advanced technology case and in the *CEF* cases is more uncertain and represents a higher level of risk for the ultimate success and timing of the technology improvement. Furthermore, the simultaneous success of a wide range of technology development projects is highly unlikely. Because the reference case is based on historical levels of funding and technology development, the technology trends assumed in the reference case are considered to be the most likely trends. However, of the cases considered in this study, this is the case for which it is most costly to reduce emissions.

- Relative to the reference case, the advanced technology case and the cases with the *CEF* policies all reduce projected energy demand, energy prices, and related emissions. Total energy demand in 2020 is projected to be similar in the advanced technology case and the case incorporating the *CEF* moderate policies, with the lowest demand in the case incorporating the *CEF* advanced policies. Because the advanced technology case also includes more rapid technology development for fossil fuel supply, that case has the lowest projected energy prices.

- As a result of lower energy prices and demand, the advanced technology and the *CEF* cases have lower projected energy expenditures than in the reference case.

Cases with Emissions Limits

- In general, the emissions limits are achieved through a combination of reductions in energy demand, shifts from coal-fired electricity generation to existing nuclear, natural gas, and renewable generation, and additional emissions control equipment. Within the time frame of the emissions limits, economical technologies to capture and sequester CO_2 emissions are unlikely, although these technologies are included in the analysis. In addition, Hg emissions control technologies are relatively new and untested on a commercial scale. As a result, their cost and performance are highly uncertain.

- CO_2 emissions permit costs are included in the price of the fossil fuel to electricity generators. For the other three emissions, the permit costs are included in the electricity price if the unit is the marginal generator. All cases assume a marketable emissions permit system with an allocation of permits based on historical emissions.

- In 2020, the allowance prices for SO_2 range from \$221 to \$905 per ton (1999 dollars), NO_x from zero to \$81 per ton, Hg from \$306 to \$468 million per ton, and CO_2 from \$50 to \$122 per metric ton carbon equivalent. The efforts to reduce NO_x, SO_2, Hg, and CO_2 emissions are linked. Emissions control equipment added to reduce NO_x and SO_2 also leads to lower Hg emissions. Similarly, because reducing CO_2 typically leads to lower coal use, it also lowers NO_x, SO_2, and Hg emissions. As a result, all of the allowance prices are also interrelated; and, if the emission target for one were changed, all of the allowance prices would likely change.

- Reducing energy demand relative to the reference case by encouraging the development and adoption of more energy-efficient technologies or lowering the demand for energy services makes the emissions limits less costly to achieve. In 2020, total energy demand is reduced by between 1 and 5 percent when the emissions limits are imposed.

- In each of the four cases, the total cumulative resource cost of generating electricity is projected to increase by 8 to 9 percent when the emissions limits are imposed.

- In 2020, the increase in projected electricity prices due to the emissions limits ranges from zero to 33 percent. In the case incorporating the *CEF* advanced policies, imposing the emissions limits is not expected to result in higher electricity prices, primarily due to the \$50 per ton carbon fee already included in the case without emissions limits.

- Imposing the emissions limits on each of the four cases is projected to raise the demand for natural gas due to increased use by electricity generators that are subject to the emissions limits. Natural gas demand is also projected to be higher for commercial and industrial cogeneration in all cases except the case with the advanced *CEF* policies. This case is the exception because the \$50 per ton carbon fee in the case without limits is essentially the same as the CO_2 permit price that results when the emissions limits are imposed. As a result of higher projected natural gas demand, natural gas prices in 2020 are projected to be higher by between 11 and 20 percent in all four cases when the emissions limits are imposed.

- Because the *CEF* advanced policies include a \$50 per ton carbon fee and a policy to reduce particulate emissions, coal consumption is sharply reduced in that case and electricity prices are higher relative to the reference case, even without the emissions limits. Because of the \$50 per ton carbon fee, imposing emissions limits does not cause a significant additional reduction in total energy demand in that case.

- Although the total energy expenditures are lower in the advanced technology and *CEF* cases than in the reference case, energy expenditures are expected to increase when the emissions limits are imposed in all cases.

- Meeting the individual emission limits for NO_x, SO_2, Hg, and CO_2 will all require significant effort; the CO_2 and Hg limits are likely to be the most difficult to meet. While there is some uncertainty, technologies exist that would allow electricity generators to meet the NO_x and SO_2 limits without switching fuels. However, meeting the assumed Hg limit of 4.3 tons probably would require some fuel switching. This limit for Hg implies removing 95 percent of the Hg in the coal used by electricity generators today. For many combinations of plant and coal type, existing technology may not be able to achieve this level of removal. Similarly, to meet the assumed CO_2 limit, significant switching from coal to other fuels is expected, because low-cost technologies for capturing and sequestering CO_2 are not expected to be widely available in the time frame of this analysis.

- The assumed emissions limits are expected to have measurable short-term impacts on the economy when the limits are fully imposed in 2007, with a reduction in gross domestic product ranging from 0.4 to 0.8 percent. However, the impact is significantly reduced even by 2010, as the economy adjusts to higher energy prices. In all cases except the reference case, the macroeconomic impacts of the emissions limits are essentially eliminated by 2020.

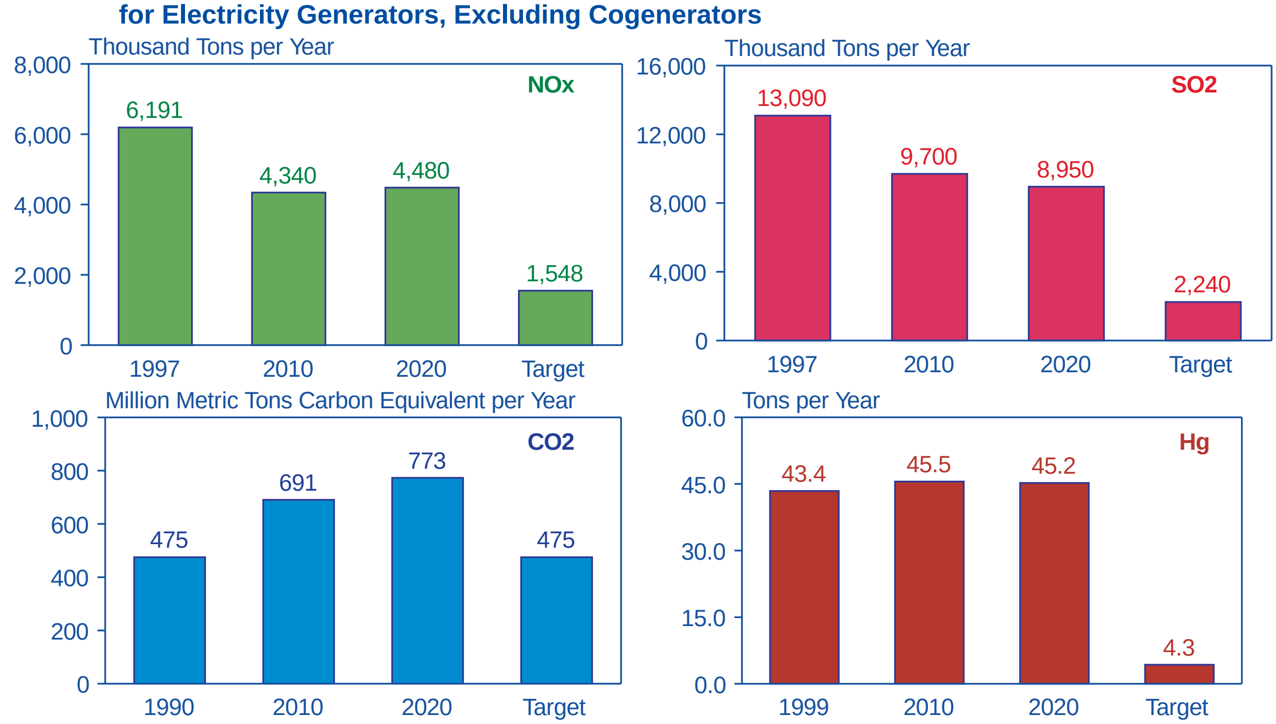
Executive Summary

Introduction

The analysis in this report was undertaken at the request of Senators James M. Jeffords (I-VT) and Joseph I. Lieberman (D-CT) to analyze the potential impacts of limits on four emissions from electricity generators, sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and mercury (Hg). In July 2001, the Energy Information Administration (EIA) published the report *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard.*[1] In that report, EIA analyzed the impacts of a number of different limits for SO_2, NO_x, CO_2, and Hg emissions from electricity generators, which varied by level and start year, and a renewable portfolio standard. The analysis was conducted relative to the reference case of the *Annual Energy Outlook 2001* (*AEO2001*),[2] published in December 2000, using EIA's National Energy Modeling System (NEMS).

For this analysis, Senators Jeffords and Lieberman requested that EIA consider the impacts of technology improvements and other market-based opportunities on the costs of emissions reductions from electricity generators. Using 2002 as a start date for emissions reductions, the request specifies that by 2007 NO_x emissions from electricity generators are to be reduced to 75 percent below 1997 levels, SO_2 emissions to 75 percent below the full implementation of the Phase II requirements under Title IV of the Clean Air Act Amendments of 1990 (CAAA90), Hg emissions to 90 percent below 1999 levels, and CO_2 emissions to 1990 levels (Figure ES1). These emissions limits are applied to all electricity generators, excluding cogenerators, which produce both electricity and useful thermal output and account for less than 10 percent of total generation. (Throughout this report cogenerators are excluded when reference to electricity generators is made.) The impacts of these limits are analyzed against four different cases with varying levels

Figure ES1. Historical Emissions, Reference Case Projections for 2010 and 2020, and Target Caps for Electricity Generators, Excluding Cogenerators



Sources: **History:** Energy Information Administration, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). **Projections:** National Energy Modeling System, run SCENABS.D080301A.

[1]Energy Information Administration, *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard*, SR/OIAF/2001-03 (Washington, DC, July 2001), web site www.eia.doe.gov/oiaf/servicerpt/epp/index.html.

[2]Energy Information Administration, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001) (Washington, DC, December 2000), web site www.eia.doe.gov/oiaf/aeo/index.html.

of energy demand: the reference case from *AEO2001*, a case combining the high technology assumptions for end-use demand, supply, and generating technologies from *AEO2001*, and the moderate and advanced policy cases from *Scenarios for a Clean Energy Future* (*CEF*), a publication of an interlaboratory working group, published in November 2000 (Table ES1).[3] In general, the emissions limits are achieved through a combination of reductions in energy demand, shifts from coal-fired electricity generation to nuclear, natural gas, and renewable generation, and additional emissions control equipment. Within the time frame of the emissions limits, economical technologies to capture and sequester CO_2 are unlikely. Sequestration technologies are included in the analysis but do not penetrate because they are not economical.

Table ES1. Description of the Analysis Cases

Case Name	Description	Emissions Limits
CEF business-as-usual	Reference case in the *CEF* report. Prepared using a revision of the *Annual Energy Outlook 1999* version of the National Energy Modeling System, which is known as *CEF*-NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
CEF moderate	Case in the *CEF* report adding the moderate *CEF* policies to the *CEF* business-as-usual case. Prepared using *CEF*-NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
CEF advanced	Case in the *CEF* report adding the advanced *CEF* policies to the *CEF* business-as-usual case. Prepared using *CEF*-NEMS.	Reduces SO_2 emissions from electricity generators in steps between 2010 and 2020 to 4.48 million tons to simulate a particulate reduction policy. Includes a domestic CO_2 trading system across all energy sectors, which is assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent.
Reference	EIA reference case for this analysis, incorporating some revisions to the *Annual Energy Outlook 2001* reference case. Prepared using NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
Reference with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above reference case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements.
Advanced technology	EIA case incorporating the *Annual Energy Outlook 2001* high technology assumptions for end-use demand, generation, and fossil fuel supply technologies to the reference case. Prepared using NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
Advanced technology with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above advanced technology case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements.
CEF-JL moderate	EIA case incorporating the moderate *CEF* policies in the reference case. Prepared using NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
CEF-JL moderate with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above *CEF-JL* moderate case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements.
CEF-JL advanced	EIA case incorporating the advanced *CEF* policies in the reference case. Prepared using NEMS.	Reduces SO_2 emissions from electricity generators in steps between 2010 and 2020 to 4.48 million tons to simulate a particulate reduction policy. Includes a domestic CO_2 trading system across all energy sectors, which is assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent.
CEF-JL advanced with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above *CEF-JL* advanced case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements. Includes a domestic CO_2 trading system across all energy sectors, which is assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

[3]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), web site www.ornl.gov/ORNL/Energy_Eff/CEFOnep.pdf.

The cost to electricity generators of meeting the emissions limits by installing emissions control equipment or purchasing emissions permits is included in the price of electricity, to the extent to which these costs can be passed through to consumers. CO_2 emissions permit costs are effectively included in the price of the fossil fuel to electricity generators. For the other three emissions, the permit costs are included in the electricity price based on the cost incurred by the marginal generator. All cases assume a marketable emissions permit system with an allocation of permits based on historical emissions.

In accordance with the request from Senators Jeffords and Lieberman, this study is based on the reference case of *AEO2001*. In accordance with the requirement that the EIA reference case projections be policy-neutral, the *AEO2001* projections generally assume that all Federal, State, and local laws, regulations, policies, and standards in effect as of July 1, 2000, remain unchanged through 2020. Potential impacts of pending or proposed legislation, proposed standards, legislation or regulations for which all specifics were not yet defined, or sections of existing legislation for which funds had not been appropriated prior to the preparation of *AEO2001* are not included in the projections. The reference case also assumes the transition to full competitive pricing of electricity in those States with specific restructuring plans.

Several revisions have been made to the *AEO2001* reference case for this study to update to more current energy markets, including higher estimated natural gas consumption and prices for 2000 and 2001. The new appliance efficiency standards issued by the U.S. Department of Energy (DOE) in January 2001 for residential and commercial equipment are also included, as modified by the Bush Administration. Finally, in order to allow for the analysis of Hg emissions and control technologies, modifications have been made to both the electricity generation and coal supply portions of NEMS since *AEO2001*.

The reference case projections in this analysis represent business-as-usual forecasts, given known trends in technology development and demographics, current laws and regulations, and the specific methodologies and assumptions used by EIA. Results from any model or analysis are highly uncertain. Energy models are simplified representations of complex energy markets. The results of any analysis are highly dependent on the specific data, assumptions, behavioral characteristics, methodologies, and model structures included. In addition, many of the factors that influence the future development of energy markets are highly uncertain, including weather, political and economic disruptions, technology development, and policy initiatives. The results of the various cases should be considered as relative changes to the comparative baseline cases.

Future technology development cannot be known with certainty, and even the technology improvements assumed in the reference case are likely, but not certain. The more rapid technology development assumed in the EIA advanced technology case and in the cases incorporating the policies of *CEF* are more uncertain and represent a higher level of risk for the ultimate success and timing of the technology improvements. It is possible that even more rapid technology development than assumed in the advanced technology case or breakthrough technology development could occur. In particular, Hg emissions control technologies are relatively new and untested on a commercial scale. As a result, their cost and performance are highly uncertain.

The projected price of natural gas is also subject to uncertainty. Nearly all new electricity generation capacity is expected to be fueled by natural gas. If the price of natural gas were to be higher than projected in this analysis, coal-fired generation would become more economic, which would, in turn, cause the emissions limits to be more costly to achieve.

In addition, electricity markets are undergoing a transition from average-cost regulated pricing to market-based pricing. This analysis assumes that wholesale generation markets will function competitively and that the costs of achieving the emissions limits that increase the operating costs at plants setting the market price of electricity will be passed to consumers. If the markets function in a different manner, the costs and prices could be different.

Impacts of Emissions Limits on the Reference and Advanced Technology Cases

Reference Case

In the reference case without emissions limits, total energy consumption is projected to increase at an average annual rate of 1.4 percent between 1999 and 2020, reaching 128 quadrillion British thermal units (Btu) (Table ES2). This is based on projected economic growth of 3.0 percent per year. Due to efficiency improvements in the use of energy and a shift in the economy from more energy-intensive industries, the energy intensity of the economy, measured as energy use per dollar of real gross domestic product (GDP), is projected to decline at an average annual rate of 1.6 percent.

Introducing the emissions limits in the reference case raises the projected average delivered price of electricity by 33 percent in 2020 relative to the reference case (Figure ES2). Electricity prices are higher because of the additional costs for emission control equipment, the costs of obtaining emissions permits, and higher fossil fuel prices to electricity generators.

Overall, the higher electricity prices reduce the projected demand for electricity (Figure ES3), although the impact is dampened by the higher projected natural gas price, which results from higher demand for natural gas. Coal-fired electricity generation is expected to be reduced with the imposition of the emissions limits, and, due to the retirement of coal-fired generators, generation from natural gas, renewable, and existing nuclear technologies is higher, even with lower generation requirements (Figure ES4). As a result of higher energy prices, energy expenditures are projected to be higher than in the reference case without emissions limits.

Table ES2. Energy Market Projections in the Reference and Advanced Technology Cases, 2020

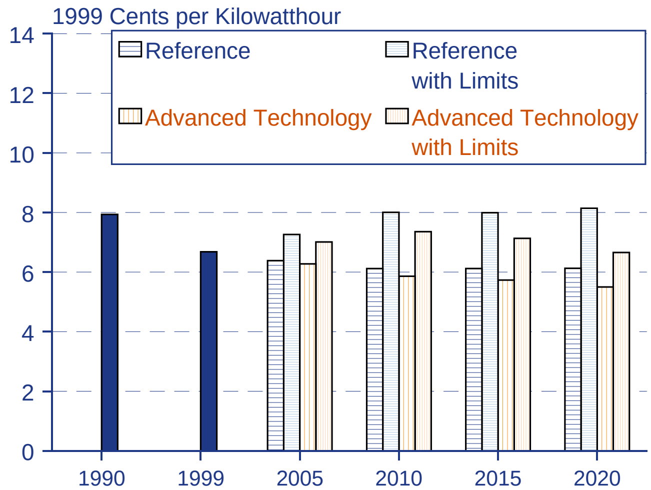
Projections	1999	2020			
		Reference		Advanced Technology	
		Without Emissions Limits	With Emissions Limits	Without Emissions Limits	With Emissions Limits
Primary Energy Consumption (Quadrillion Btu)					
Petroleum	37.9	50.4	50.3	45.7	45.9
Natural Gas	22.3	35.9	39.3	33.2	36.5
Coal	21.4	26.3	13.3	25.1	14.1
Nuclear Power	7.8	6.5	7.2	7.2	7.7
Renewable Energy	6.5	8.4	10.5	9.1	10.6
Total	**96.3**	**127.7**	**120.9**	**120.4**	**115.2**
Change in Primary Energy Intensity (Annual Percent Change, 1999-2020)	**—**	**-1.6**	**-1.9**	**-1.9**	**-2.1**
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,763**	**4,320**	**4,610**	**4,294**
Electricity Generation, Excluding Cogenerators (Billion Kilowatthours)					
Coal	1,830	2,302	1,041	2,246	1,146
Petroleum	85	23	11	16	10
Natural Gas	370	1,488	2,072	1,331	1,911
Nuclear Power	730	610	669	672	720
Renewables	355	399	519	409	524
Total	**3,369**	**4,821**	**4,311**	**4,674**	**4,309**
Electricity Generation by Cogenerators (Billion Kilowatthours)	**303**	**440**	**664**	**444**	**608**
Prices					
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	3.10	3.72	2.20	2.60
Coal Minemouth Price (1999 Dollars per Short Ton)	17.13	12.93	12.61	10.76	10.97
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.1	8.1	5.5	6.7
Cumulative Resource Cost for Electricity Generation, 2001-2020 (Billion 1999 Dollars)	**—**	**2,031**	**2,208**	**1,837**	**1,979**
Emissions[a]					
CO_2 (Million Metric Tons Carbon Equivalent)[b]	1,511	2,044	1,757	1,884	1,653
SO_2 (Million Tons)	13.5	9.0	2.2	9.0	2.2
NO_x (Million Tons)	5.4	4.5	1.4	4.3	1.6
Hg (Tons)	43.4	45.2	4.3	45.1	4.3
Allowance Prices					
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	122	0	58
SO_2 (1999 Dollars per Ton)	0	200	221	145	703
NO_x (1999 Dollars per Ton)[c]	0	0	0	0	0
Hg (Million 1999 Dollars per Ton)	0	0	306	0	374

[a] CO_2 emissions are from all energy sectors. Other emissions are from electricity generators, excluding cogenerators.
[b] CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
[c] Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

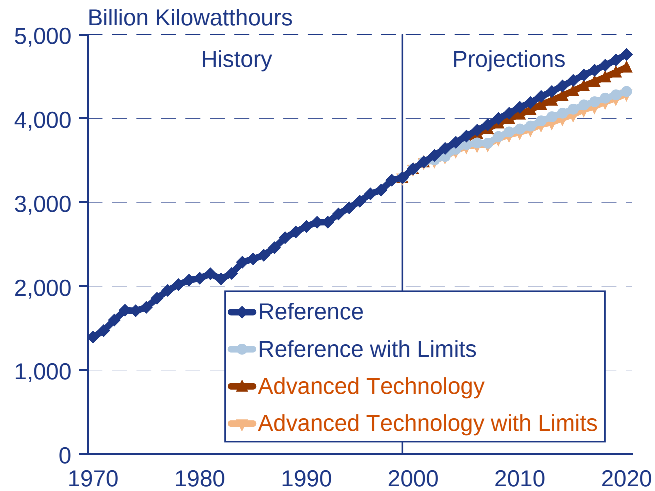
The total cost of supplying electric power, which is called the resource cost, includes the cost of fuel, operations and maintenance costs, investments in plant and equipment, and costs of purchasing power. The resource cost does not include the costs of emissions allowances, which are included in the price of electricity. From 2001 through 2020, the cumulative resource costs of electricity generation are projected to be $177 billion (undiscounted 1999 dollars), or 9 percent, higher with the emissions limits (Figure ES5).

Figure ES2. Average Delivered Electricity Prices in Four Cases, 1990-2020



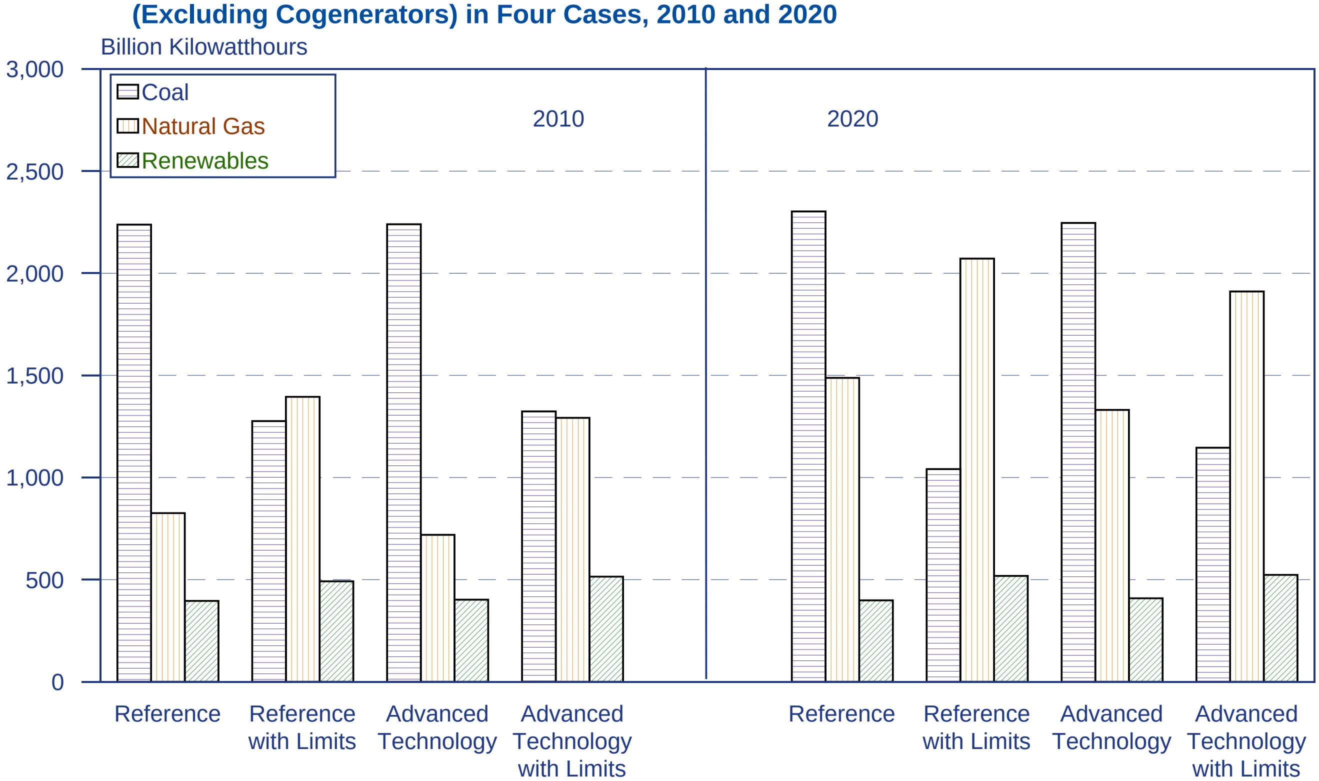
Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and

Figure ES3. Electricity Sales in Four Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and

Figure ES4. Projected Electricity Generation from Coal, Natural Gas, and Renewable Fuels (Excluding Cogenerators) in Four Cases, 2010 and 2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM. D081701A.

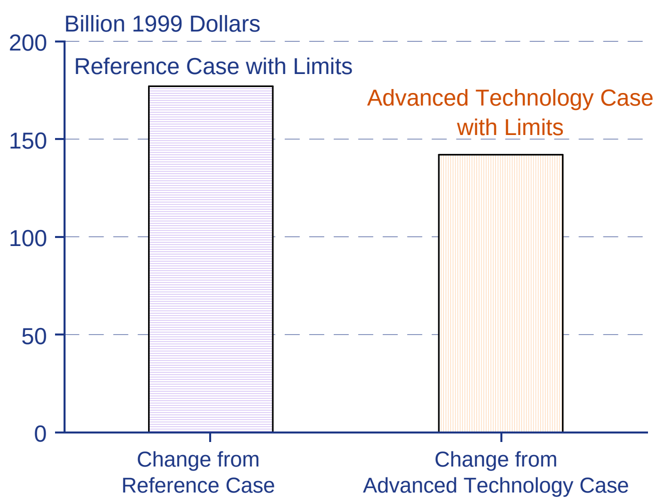
Natural gas consumption is expected to be higher, primarily for electricity generation by generators subject to emissions limits as they reduce coal-fired generation. Higher demand for natural gas is also expected in the commercial and industrial sectors as they increase the cogeneration of electricity, which is assumed not to be subject to the emissions limits.[4]

Advanced Technology Case

The reference case assumes continued improvements in technology for energy consumption, electricity generation, and fossil fuel production, based on historical rates of improvement. The advanced technology case analyzed in this study combines the high technology assumptions for end-use demand, electricity generation technologies, and fossil fuel supply in *AEO2001*. For the high technology cases in *AEO2001*, the reference case technology assumptions are modified to include earlier years of introduction, lower costs, higher maximum market potential, or higher efficiencies than assumed in the reference case or a combination of these assumptions.

To represent more rapid technology development in the electricity generation sector, the costs and efficiencies of advanced fossil-fired and new renewable generating technologies are assumed to improve from reference case values. In the advanced technology case, the aging-related cost increases for nuclear power plants are assumed to be lower than those in the reference case. For oil and gas supply, the assumed rate of technological progress is accelerated relative to the reference case, increasing supplies and reducing production costs. More rapid technology development in coal production is assumed by increasing labor productivity and reducing labor and equipment costs, relative to the reference case.

Figure ES5. Impacts of Emission Limits on Cumulative Resource Costs for Electricity Generation, 2001-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

All of these assumptions for more rapid improvements in technology, based on higher levels of research and development funding than assumed in the reference case, result in the successful development of the technologies. More rapid technology development could be possible with higher funding or breakthrough developments. The levels of funding necessary for the successful achievement of the technology characteristics assumed in the advanced technology case are not known, nor are the environmental benefits quantified. However, the simultaneous success of all technology research is highly unlikely. History has shown that funding levels for research and development cannot be tied directly to the successful development of new technologies. Because the reference case is based on historical levels of funding and technology development, the technology trends assumed in the reference case are considered to be the most likely trends.

As a result of rapid technology development in the advanced technology case without emissions limits, total energy consumption is projected to be reduced by 7 quadrillion Btu in 2020, or 6 percent, relative to the reference case without emissions limits, due to the earlier adoption of more efficient technologies in the end-use demand sectors. Overall, the energy intensity of the economy is projected to decline at an average annual rate of 1.9 percent between 1999 and 2020, compared with 1.6 percent in the reference case without emissions limits. Projected consumption of all fossil fuels and electricity is lower than in the reference case; however, the use of existing nuclear power and renewable technologies is projected to be higher due to the assumed cost and performance improvements. Because of reduced energy consumption and the shift in the fuel mix to more renewables and nuclear power, projected CO_2 emissions in 2020 are reduced by 8 percent.

Partly due to lower projected consumption but primarily due to the more rapid technology development assumed for the production of fossil fuels, the prices of both natural gas and coal are expected to be reduced. Because the price of crude oil is assumed to be set on world markets, the projected price of oil does not change.[5] Lower projected prices for natural gas and coal, combined with lower electricity demand that reduces the need for new capacity, contribute to lower electricity prices. However, the impact of the lower prices on energy consumption is small relative to the impact of the more rapid technology improvement in

[4]At this time, limits on emissions from cogeneration are not represented.

[5]For this study, the potential for worldwide technology improvements in oil production was not addressed.

the energy-consuming sectors. Projected energy expenditures are lower relative to the reference case due to lower energy demand and prices.

Imposing the emissions limits on the advanced technology case raises the projected average delivered price of electricity by 22 percent in 2020, less than the increase in the reference case. Lower projected demand for electricity and the use of less carbon-intensive fuels in the advanced technology case relative to the reference case reduce the effort needed to meet the emissions limits. Among the four emissions that have limits in these cases, CO_2 emissions tend to be the most costly to reduce, largely through the premature retirement of existing coal plants and the increased use of natural gas and renewable technologies. CO_2 sequestration is included in NEMS, but currently there are no economical technologies to sequester CO_2 emissions from generation plants, unlike the technologies available for the removal of the other three emissions.

Because the advanced technology case without limits has lower CO_2 emissions than the reference case, fewer shifts in electricity generation are required to meet the CO_2 limits when the limits are imposed. In addition, because reductions in CO_2 emissions also reduce SO_2 and Hg emissions, it is more costly to achieve reductions of these emissions in the advanced technology case than in the reference case. Additional investments in emissions control equipment are required to meet the limits. Similar to the reference case, NO_x allowance prices are projected to decline to zero in the advanced technology case with emissions limits.

When the emissions limits are imposed in the advanced technology case, the higher electricity prices reduce the projected demand for electricity, but the reduction is less than projected in the reference case when the emissions limits are imposed, because the projected demand for electricity is already lower in the advanced technology case even without the limits, and because the projected increase in the electricity price is less than in the reference case. Similar trends in the generation mix are expected, although the magnitudes of the changes differ as the result of lower generation requirements and the higher level of renewable and nuclear generation already expected in the advanced technology case without emissions limits. Similar to the reference case, demand for natural gas is expected to be higher when emissions limits are imposed in the advanced technology case, due to fuel switching by electricity generators and increased cogeneration in the commercial and industrial sectors. Higher projected prices result in higher energy expenditures in the advanced technology case when the limits are imposed.

From 2001 through 2020, the incremental cumulative resource costs of complying with the emissions limits in the advanced technology case are projected to be $142 billion (an 8-percent increase), compared with $177 billion (a 9-percent increase) in the reference case.

Impacts of Emissions Limits in 2007 on the Reference and Advanced Technology Cases

Emissions reductions are assumed to begin in 2002, reaching the full limits in 2007. In the reference case with emissions limits, average delivered electricity prices in 2007 are projected to be 32 percent higher than in the reference case (Table ES3). The higher electricity price results from the purchase of emissions permits and investments in emissions control equipment. Between 2006 and 2007, when the emissions limits are fully imposed, the price of electricity is expected to increase by 6 percent.

As the limits are imposed on the reference case, coal-fired generation is projected to decline and natural gas and renewable generation are projected to increase, with a slight increase in generation from existing nuclear power plants as well in 2007. As a result, the projected natural gas price in 2007 is 17 percent higher when the emissions limits are imposed on the reference case.

There are implications for the economy as a result of the emissions limits and the projected higher energy prices. Consumers and business both would spend more for energy, causing increases in the prices of goods and services throughout the economy. Real GDP in 2007 is projected to be reduced by 0.8 percent in the reference case when the emissions limits are imposed. However, these impacts become smaller as the economy adjusts to higher prices. In 2010 and 2020, GDP in the reference case with emissions limits is projected to be 0.3 percent below the level in the reference case, as the economy adjusts to the higher prices.

In the advanced technology case, energy consumption is expected to be lower than in the reference case, resulting in smaller impacts from the emissions limits. In the advanced technology case with emissions limits, projected average delivered electricity prices in 2007 are 30 percent higher than in the case without the limits. In the advanced technology case with emissions limits, the projected average delivered electricity price increases by 7 percent between 2006 and 2007.

When the limits are imposed on the advanced technology case, shifts in generation similar to those in the reference case are projected to occur. The natural gas price is expected to be 17 percent higher in 2007. As a result of higher energy prices, real GDP in 2007 is projected to be reduced by 0.7 percent in the advanced technology case when the emissions limits are imposed. In 2010 and 2020, the reductions in GDP in the advanced technology case with emissions limits are projected to be 0.2 percent and 0.1 percent, respectively, from the levels in the advanced technology case.

Impacts of Emissions Limits Using the *Clean Energy Futures* (*CEF*) Policies

CEF

The *CEF* study was commissioned by DOE's Office of Energy Efficiency and Renewable Energy. The report was prepared by an interlaboratory working group from Argonne National Laboratory, Lawrence Berkeley National Laboratory, the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory. The purpose of *CEF* was to analyze the impacts of various energy policies and programs that would promote "clean energy technologies," which include reducing the energy intensity of the economy, reducing the CO_2 intensity of the energy used, and integrating the sequestration of CO_2 into energy production and delivery.

CEF analyzed business-as-usual, moderate, and advanced cases. The business-as-usual case, which assumed current energy policies and programs as of the time *CEF* was prepared and continued technological improvement, was based on the reference case from the *Annual Energy Outlook 1999* (*AEO99*), the most recent *Annual Energy Outlook* available at the time the *CEF* analysis was initiated. The *CEF* working group developed a revised version of NEMS (referred to as *CEF*-NEMS). The most significant changes in the business-as-usual case were revisions to three of the energy-intensive industries in the industrial sector, which reduced projected primary energy consumption in 2020 by 1 quadrillion Btu, and a reduction in the costs of nuclear plant refurbishment and relicensing, resulting in fewer nuclear plant retirements and making it easier to reduce CO_2 emissions.

The policies in the moderate and advanced cases in *CEF* included fiscal incentives, voluntary programs, efficiency standards, regulations, and increased research and development funding. In general, the advanced case included additional or extended programs relative to the moderate case. The advanced case also included a domestic CO_2 trading system that was assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent, which would be announced in 2002 and implemented in 2005. As requested, this analysis incorporates the *CEF* policies where possible. However, several general issues are noted:

- Many of the *CEF* policies are based on additional funding for technology research and development, totaling $1.4 billion (1997 dollars) per year in the moderate case and $2.8 billion per year in the advanced case, with costs shared between the public and private sectors. It is difficult, however, to

Table ES3. Energy Market Projections in the Reference and Advanced Technology Cases, 2007

Projections	1999	2007			
		Reference		Advanced Technology	
		Without Emissions Limits	With Emissions Limits	Without Emissions Limits	With Emissions Limits
Primary Energy Consumption (Quadrillion Btu)	96.3	110.7	106.1	109.2	104.8
Change in Primary Energy Intensity (Annual Percent Change, 1999-2007)	—	-1.6	-2.0	-1.8	-2.2
Electricity Sales (Billion Kilowatthours)	3,294	3,926	3,703	3,878	3,691
Gross Domestic Product (Billion 1996 Dollars)	8,876	11,605	11,508	11,605	11,523
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	2.86	3.35	2.58	3.03
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.2	8.2	6.0	7.8
Emissions[a]					
CO_2 (Million Metric Tons Carbon Equivalent)[b]	1,511	1,750	1,563	1,712	1,536
SO_2 (Million Tons)	13.5	10.1	3.5	10.1	3.6
NO_x (Million Tons)	5.4	4.3	1.7	4.2	1.8
Hg (Tons)	43.4	45.4	4.3	45.6	4.3
Allowance Prices					
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	85	0	78
SO_2 (1999 Dollars per Ton)	0	177	5	174	85
NO_x (1999 Dollars per Ton)[c]	0	0	1,135	0	1,223
Hg (Million 1999 Dollars per Ton)	0	0	680	0	638

[a]CO_2 emissions are from all energy sectors. Other emissions are from electricity generators, excluding cogenerators.
[b]CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
[c]Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

quantify the impact of increased funding on specific improvements in technology development, as noted for the advanced technology case. Because these funding increases are questionable and the link between funding and technology development is tenuous, the technology improvements in *CEF* based on these research and development policies are also questionable. Although the environmental benefits, which are not quantified, could be higher in the advanced case than in the moderate case, the associated costs would also be higher.[6]

- Many *CEF* policies, particularly in the industrial sector, relied on voluntary and information programs whose impacts are difficult to quantify.

- Some of the *CEF* policies required legislative or regulatory actions that may not be enacted at all or may be enacted at later dates than assumed in *CEF*. These included tax credits for certain high-efficiency vehicles and renewable generation technologies, new equipment standards, national electricity industry restructuring, a renewable portfolio standard (which requires a specified percentage of electricity sales to be generated from renewable sources other than hydropower), new particulate standards, and pay-at-the-pump motor vehicle insurance.

- Certain technology cost reductions in the *CEF* analysis appear unrealistic. For example, in the residential sector, the cost of the most efficient unit for some appliances was reduced to the cost of the least efficient unit. It seems unlikely that either research and development or voluntary programs could reduce technology costs to that level. Other technology assumptions also appear unrealistic—for example, the assumption that generating plants using CO_2 sequestration technology would achieve the same efficiency as those that do not.

- In the residential and commercial sectors, consumer hurdle rates were significantly reduced. These hurdle rates represent the willingness of consumers to invest in energy-efficient equipment. Although the hurdle rate reductions in the *CEF* analysis were attributed to voluntary programs and other policies, they appear to be very optimistic in their valuation of consumer desire for energy efficiency.

- In the *CEF* analysis, the growth rates of miscellaneous electricity uses in both the residential and commercial sectors were significantly reduced. These modifications were largely attributed by the *CEF* authors to voluntary programs, State market transformation programs, and, in the advanced case, a 2004 commercial transformer standard. The reductions in the growth rates appear unrealistic because it is unlikely that the use of some of the equipment in these categories, such as automated teller machines, medical and telecommunications equipment, and small appliances, would be greatly reduced. Although there is the potential for some efficiency improvements, it is unlikely that efficiencies could improve enough to reach the consumption levels achieved in *CEF*. Some of these small appliances include heating elements that cannot readily incorporate increased efficiency.

- From a macroeconomic perspective, the crucial assumption underlying the *CEF* study was that the economy is not currently using its resource base efficiently; i.e., the economy is not on the production possibilities curve. The study assumed that overcoming large-scale market failures can place the economy on this frontier with less energy use and fewer emissions. However, many of the presumed market failures are actually rational, efficient decisions on the part of consumers given current technology, expected prices for energy and other goods and services, and the value they place on the time they would take to evaluate their options. As Henry Jacoby points out, "The key difference between market barriers and market failures is that correcting failures may sometimes produce a net benefit, whereas overcoming barriers always involves cost."[7]

CEF projected that the policies in the moderate case could reduce total energy consumption by 8 percent in 2020 relative to the business-as-usual case. Total energy consumption was projected to increase at an average annual rate of 0.7 percent between 1997 and 2020, compared with 1.1 percent in the business-as-usual case.

In the advanced case, *CEF* projected that the more aggressive policies would reduce total energy consumption by 19 percent in 2020 relative to the business-as-usual case. Total projected energy consumption increased at an average rate of 0.4 percent per year through 2010, then decreased from 2010 through 2020 at an average rate of 0.3 percent per year. An actual decrease in energy consumption as projected in *CEF* would appear unlikely without significant increases in energy prices. In both cases, *CEF* projected lower fossil fuel consumption, fewer nuclear power retirements, and more renewable energy than in the business-as-usual case.

[6]*CEF* estimated the research and development funding, plus program implementation, administrative, and incremental technology investment costs. Comparing those costs with reductions in energy expenditures, *CEF* concluded there would be a net saving. The present analysis does not estimate the costs of the *CEF* policies.

[7]H. Jacoby, "The Uses and Misuses of Technology Development as a Component of Climate Change Policy," presentation to the America Council for Capital Formation, Center for Policy Research (October 1998).

The request for this analysis to EIA specified that two cases be analyzed "assuming the moderate [advanced] supply and demand-side policy case of the Clean Energy Futures study." However, there have been significant changes to the model and to the assumptions for *AEO2000* and particularly *AEO2001*. One of the most significant changes that occurred between *AEO99* and *AEO2001* is the assumed rate of economic growth. In *AEO99*, the U.S. economy was projected to grow at an average annual rate of 2.0 percent between 1999 and 2020; however, the growth rate in *AEO2001* is projected to be 3.0 percent. The more rapid projected growth in GDP impacts the projected growth in other key economic drivers, such as commercial floorspace, industrial gross output, and real disposable personal income. In addition, the growth rate for electricity demand was reevaluated in *AEO2001*, particularly for computers, office and other electrical equipment and appliances, and miscellaneous energy uses, in accordance with recent trends.

The primary energy intensity of the U.S. economy is projected to decline at an average annual rate of 1.6 percent in *AEO2001*, compared with 1.0 percent in *AEO99*, due in part to the effects of Executive Order 13123, signed in June 1999, mandating reduced energy use in Federal facilities, a new fluorescent ballast standard promulgated in September 2000, and a reevaluation of industrial energy intensity improvements for *AEO2001*.

Other changes in the projections and assumptions between *AEO99* and *AEO2001* include higher projected natural gas and electricity prices, which affect the economics of technology adoption and penetration, and changes in technology assumptions. In some cases, the *CEF* policies overlap with or have been overtaken by changes that have occurred over time or within NEMS. For example, some policies were expected in the *CEF* analysis to be instituted in 2000 or 2001, which is no longer plausible. Also, residential equipment standards proposed in *CEF* were modified for this analysis to account for the standards announced in January 2001, as modified by the Bush Administration. Modeling enhancements have also been made to NEMS since the *AEO99* version, some of which have noticeable impacts on the projections in *AEO2001* or in the application of the *CEF* policies.

The cases implementing the *CEF* moderate and advanced policies in the current version of NEMS for this analysis are denoted as the *CEF-JL* cases (*Clean Energy Futures* – Jeffords / Lieberman). Where possible, the *CEF* policies were explicitly represented in the current version of NEMS, such as tax credits and efficiency standards. Many policies in *CEF*, including research and development and voluntary programs, were analyzed separately by the *CEF* analysts, and the results were introduced into NEMS through changes in parameters and assumptions, such as technology costs and performance and hurdle rates. For this study, EIA analysts generally implemented the same changes, on a percentage basis, in the current version of NEMS. Where *CEF* policies are date-dependent, due to the passage of time, as noted above, the *CEF* policies were adjusted for the year of implementation, which has an impact on the level of penetration.

In the request for this analysis, EIA was asked to assume the *CEF* scenarios in order to analyze the impacts of the emissions limits on projections with lower energy demand. In accordance with the request, the impacts of the policies from *CEF* were implemented for this analysis. The results of the *CEF-JL* cases should not be interpreted as an EIA analysis of the *CEF* policies, because, as noted above, EIA does not necessarily agree with the assumptions and level of impacts resulting from the policies in the *CEF* analysis. In addition, many of the *CEF* policies are dependent on increases in research and development funding or require investments in more efficient or less carbon-intensive equipment by the public and private sectors. The total cost of achieving those policies is not quantified in this analysis but is likely to be significant.

Impacts of the CEF Policies on the Reference Case

Incorporating the impacts of the *CEF* policies as presented by the *CEF* authors has a significant impact on energy markets, even without the imposition of emissions limits. Overall, primary energy consumption in 2020 is projected to be reduced from 128 quadrillion Btu in the reference case to 120 quadrillion Btu and 109 quadrillion Btu in the *CEF-JL* moderate and advanced cases, respectively (Table ES4). In the reference case, the projected decline in primary energy intensity between 1999 and 2020 averages 1.6 percent per year, which accelerates to 1.9 percent per year and 2.4 percent per year in the *CEF-JL* moderate and advanced cases, respectively. In the residential and commercial sectors, a number of *CEF* policies are aimed at reducing the demand for electricity, which has the largest projected demand reduction in both sectors. Because the *CEF-JL* advanced case includes a $50 per ton carbon fee, projected electricity prices in 2020 are higher than in the reference case, further reducing electricity demand.

In the electricity generation sector, coal-fired generation in 2020 in the reference case for this analysis is projected to be similar to that in the *CEF-JL* moderate case, but it is sharply reduced in the advanced case due to policies that encourage the use of natural gas and renewable generation, including the $50 per ton carbon fee and the *CEF* policy to reduce particulate matter emissions by reducing the SO_2 emissions level mandated in the Clean Air Act Amendments of 1990. Projected natural-gas-fired generation in both cases is lower than in the reference case primarily due to the reduced projected demand for electricity, reducing the requirements for new generation capacity that is largely natural gas fired. In 2020, generation from existing nuclear power plants is projected to have a higher share of the generation market in the *CEF-JL* cases, but nuclear generation declines slightly across the cases due to the lower electricity demand. In 2020, renewable generation is projected to be higher than in the reference case, particularly in the advanced case. In the *CEF-JL* moderate case, natural-gas-fired plants remain more economical than renewable sources; however, in the *CEF-JL* advanced case,

Table ES4. Energy Market Projections in the *CEF-JL* Moderate and Advanced Cases, 2020

Projections	1999	2020				
		Reference	*CEF-JL* Moderate		*CEF-JL* Advanced	
			Without Emissions Limits	With Emissions Limits	Without Emissions Limits	With Emissions Limits
Primary Energy Consumption (Quadrillion Btu)						
Petroleum	37.9	50.4	47.9	47.9	42.4	42.5
Natural Gas	22.3	35.9	31.3	33.8	30.7	32.0
Coal	21.4	26.3	25.8	15.7	18.3	15.5
Nuclear Power	7.8	6.5	6.4	6.9	6.1	6.6
Renewable Energy	6.5	8.4	8.6	11.5	10.8	11.1
Total	**96.3**	**127.7**	**120.2**	**116.2**	**108.7**	**107.9**
Change in Primary Energy Intensity (Annual Percent Change, 1999-2020)	**—**	**-1.6**	**-1.9**	**-2.0**	**-2.4**	**-2.4**
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,763**	**4,197**	**3,910**	**3,862**	**3,855**
Electricity Generation, Excluding Cogenerators (Billion Kilowatthours)						
Coal	1,830	2,302	2,296	1,284	1,567	1,276
Petroleum	85	23	21	11	10	9
Natural Gas	370	1,488	908	1,330	1,181	1,416
Nuclear Power	730	610	595	646	575	617
Renewables	355	399	413	624	551	561
Total	**3,369**	**4,821**	**4,231**	**3,893**	**3,883**	**3,878**
Electricity Generation by Cogenerators (Billion Kilowatthours)	**303**	**440**	**443**	**607**	**470**	**463**
Prices						
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	3.10	2.48	2.82	2.36	2.61
Coal Minemouth Price (1999 Dollars per Short Ton)	17.13	12.93	12.78	13.47	11.51	13.45
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.1	6.0	7.2	6.6	6.6
Cumulative Resource Cost for Electricity Generation, 2001-2020 (Billion 1999 Dollars)	**—**	**2,031**	**1,751**	**1,913**	**1,682**	**1,811**
Emissions[a]						
CO_2 (Million Metric Tons Carbon Equivalent)[b]	1,511	2,044	1,914	1,690	1,615	1,558
SO_2 (Million Tons)	13.5	9.0	9.0	2.2	4.5	2.2
NO_x (Million Tons)	5.4	4.5	4.3	1.7	3.2	1.6
Hg (Tons)	43.4	45.2	46.2	4.3	29.4	4.3
Allowance Prices						
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	0	68	50	50
SO_2 (1999 Dollars per Ton)	0	200	184	905	707	670
NO_x (1999 Dollars per Ton)[c]	0	0	0	81	0	0
Hg (Million 1999 Dollars per Ton)	0	0	0	468	0	391

[a]CO_2 emissions are from all energy sectors. Other emissions are from electricity generators, excluding cogenerators.
[b]CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
[c]Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

the renewable portfolio standard, the extension of production tax credits for renewables, and the $50 carbon fee encourage additional renewable generation.

Projected petroleum consumption is reduced largely due to *CEF* policies that are intended to reduce light-duty vehicle travel and improve the efficiency of all vehicles in the transportation sector, which is almost entirely dependent on petroleum. In 2020, total natural gas consumption is projected to be lower due to assumed efficiency improvements in the end-use sectors that reduce the demand for natural gas and electricity, leading to reductions in natural gas generation. Total projected coal consumption is also lower due to reduced coal-fired generation. Renewable sources are the only energy sources for which projected consumption is higher in the *CEF-JL* cases than in the reference case, mainly due to more renewable electricity generation but also due to higher use of renewables in the industrial sector in the advanced case.

Due to reduced demand, production and prices for both natural gas and coal are projected to be lower in the *CEF-JL* cases than in the reference case. Because oil prices are assumed to be set on world markets, the average crude oil price is not projected to change. Average electricity prices are expected to be lower in the *CEF-JL* moderate case than in the reference case in 2020, due to the lower price of fossil fuels and lower generation requirements, but to be higher in the *CEF-JL* advanced case due to the impact of the $50 carbon fee. Due to the reduced demand, projected energy expenditures are lower in the *CEF-JL* cases than in the reference case.

Compared to the reference case, total projected CO_2 emissions in 2020 are reduced by 6 percent and 21 percent in the *CEF-JL* moderate and advanced cases, respectively, due to the lower demand for fossil fuels. Projected emissions of SO_2, NO_x, and Hg by electricity generators are also generally reduced due to lower projected coal consumption and, in the advanced case, the policy to reduce emissions of particulate matter.

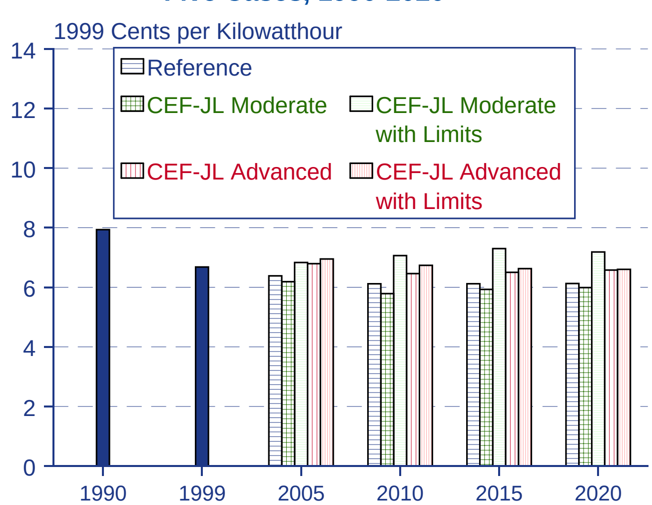
Impacts of Emissions Limits on the CEF-JL Cases

Average delivered electricity prices are expected to be higher in 2020 in the *CEF-JL* moderate case when emissions limits are imposed—7.2 cents per kilowatthour compared with 6.0 cents per kilowatthour—because of the cost of allowance permits and emissions control equipment (Figure ES6). As a result of higher electricity prices, total projected electricity consumption in 2020 is reduced (Figure ES7). However, electricity demand is essentially unchanged in the advanced case with the addition of the emissions limits, because the price is unchanged.

In the advanced case with emissions limits, the CO_2 allowance price is essentially the same as in the advanced case without the limits, which assumes a $50 carbon fee across all energy markets. The projected costs for NO_x permits decrease to zero by 2020 in the *CEF-JL* advanced case as the actions taken to reduce CO_2 emissions result in NO_x emissions within the limits.

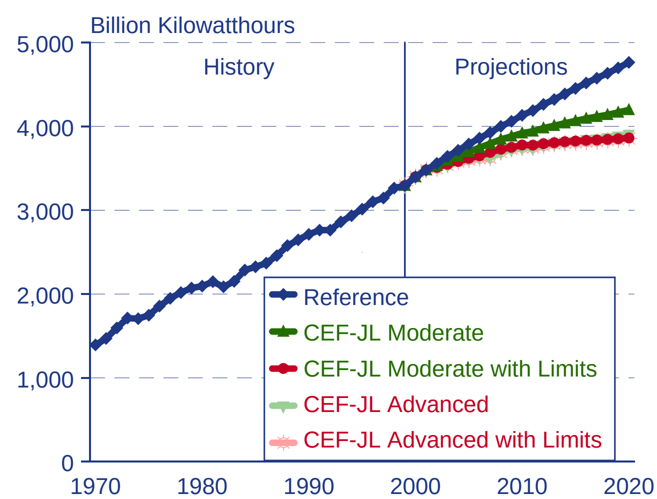
Between 2001 and 2020, the cumulative incremental resource costs to electricity generators to comply with the emissions limits are projected to be $162 billion and $129 billion in the moderate and advanced cases, respectively—increases of 9 and 8 percent (Figure ES8). The lower costs of compliance projected in the advanced case are due to the availability of more efficient generating technologies compared with the moderate case. In addition, because lower SO_2 emissions are assumed in

Figure ES6. Average Delivered Electricity Prices in Five Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure ES7. Electricity Sales in Five Cases, 1970-2020

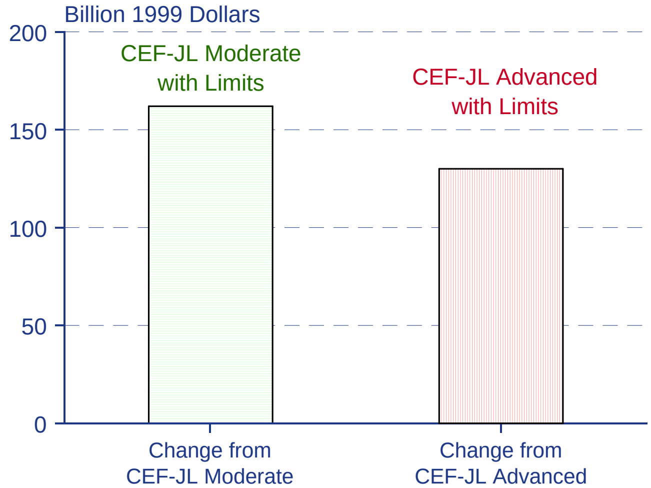


Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

the *CEF-JL* advanced case even without the emissions limits to simulate the impact of particulate controls, the addition of the emissions limits can be achieved at a lower relative cost.

Because the *CEF-JL* advanced case already includes a $50 carbon fee, there is little additional reduction in energy demand in that case when limits are imposed, and energy expenditures are only slightly higher. In the *CEF-JL* moderate case with emissions limits, higher projected prices for coal, natural gas, and electricity are projected to reduce energy consumption in the residential and commercial sectors, compared to the case without limits, and to increase total energy expenditures. In the industrial sector, projected energy consumption in 2020 is essentially unchanged because higher demand for natural gas for cogeneration offsets lower demand for purchased electricity.

Figure ES8. Impacts of Emission Limits on Cumulative Resource Costs for Electricity Generation, 2001-2020

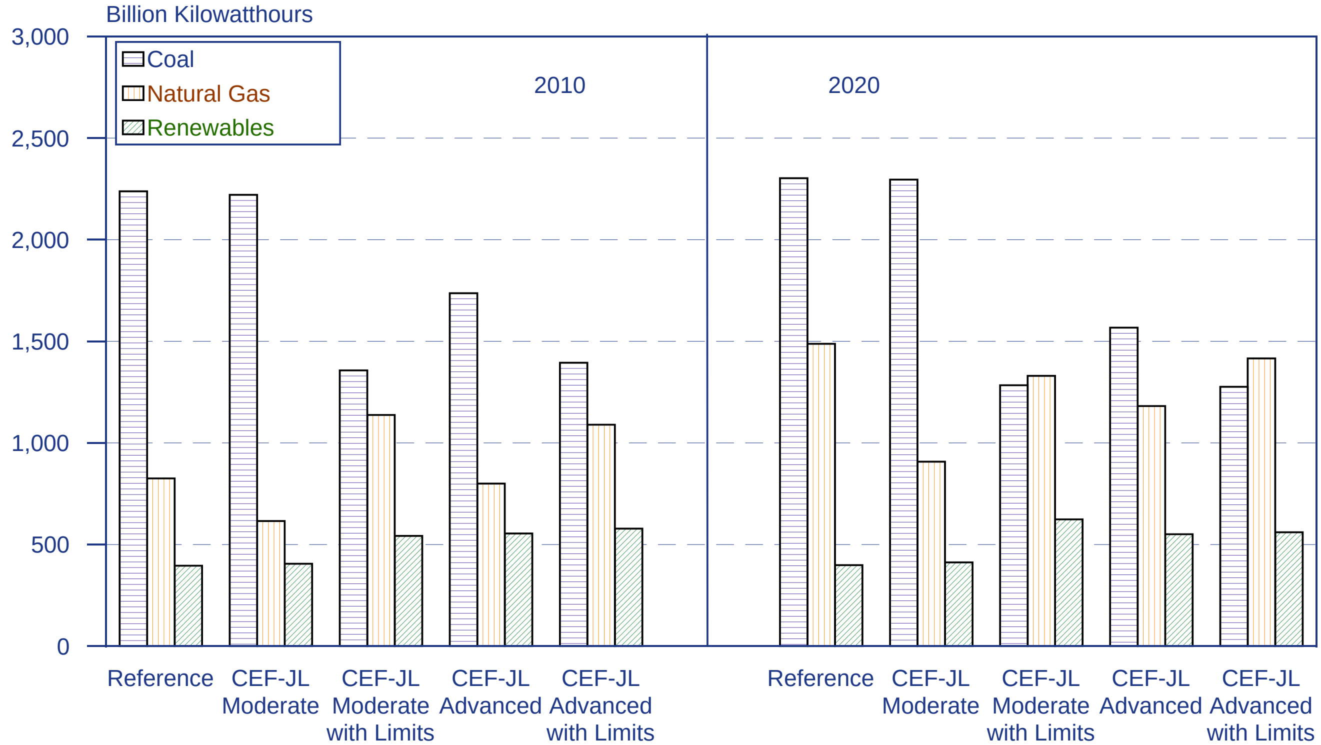


Source: National Energy Modeling System, runs SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

In the electricity generation sector, projected coal-fired generation in 2020 is reduced in the moderate and advanced cases, with the addition of the emissions limits (Figure ES9). The impact is less in the advanced case, however, because the advanced case without the limits already includes a $50 carbon fee and a reduction in particulate emissions. Generation from natural gas, existing nuclear power plants, and renewable sources is projected to be higher in both cases when the emissions limits are imposed, because the limits raise the cost of coal-fired generation. Cogeneration of electricity is also higher in the commercial and industrial sectors in the *CEF-JL* moderate case when emissions limits are imposed.

Total projected CO_2 emissions in 2020 are reduced by 12 percent and 4 percent in the *CEF-JL* moderate and advanced cases with emissions limits, respectively,

Figure ES9. Projected Electricity Generation from Coal, Natural Gas, and Renewable Fuels (Excluding Cogenerators) in Five Cases, 2010 and 2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

compared to the cases without the limits, primarily due to lower levels of coal-fired generation.

Impacts of Emissions Limits in 2007 on the CEF-JL Cases

In the *CEF-JL* moderate and advanced cases with emissions limits, average delivered electricity prices in 2007 are projected to be 27 percent and 11 percent higher, respectively, than in the cases without emissions limits (Table ES5). Between 2006 and 2007, the average delivered price of electricity in the *CEF-JL* moderate case with emissions limits is expected to increase by 7 percent; however, in the *CEF-JL* advanced case, the expected increase is only 3 percent. The lower expected price increase results from the lower demand in the *CEF-JL* advanced case and the fact that the advanced case includes a $50 carbon fee even without the emissions limits.

In both *CEF-JL* cases, there is projected to be a decrease in coal-fired generation in 2007 when the limits are imposed, with an increase in natural gas and renewable generation and a slight increase in nuclear generation. As a result, the projected natural gas price in 2007 is higher by 12 percent and 23 percent in the *CEF-JL* moderate and advanced cases than in the respective cases without limits.

In the *CEF-JL* moderate case, projected GDP in 2007 is reduced by 0.8 percent when the emissions limits are imposed. However, these impacts are reduced to 0.2 percent in 2010, and GDP is expected to return to the same level as in the case without limits by 2020. Because energy consumption is lower in the *CEF-JL* advanced case and there is a smaller increase in energy prices between 2006 and 2007 when the limits are imposed, GDP in the *CEF-JL* advanced case is projected to have approximately half the impact in the *CEF-JL* moderate case in 2007 and 2010, with GDP returning to the same level as in the case without emissions limits by 2020.

Conclusion

Reducing energy demand by encouraging the development and adoption of more energy-efficient technologies or lowering the demand for energy services makes the emissions limits less costly to achieve. However, in each of the four cases in this analysis, the total cumulative resource cost of generating electricity is projected to increase by 8 to 9 percent when the emissions limits are imposed.

Imposing the emissions limits on each of the four cases raises the projected demand for natural gas due to

Table ES5. Energy Market Projections in the *CEF-JL* Moderate and Advanced Cases, 2007

Projections	1999	2007: Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
Primary Energy Consumption (Quadrillion Btu)	96.3	110.7	108.7	105.3	104.0	102.3
Change in Primary Energy Intensity (Annual Percent Change, 1999-2007)	—	-1.6	-1.8	-2.1	-2.4	-2.5
Electricity Sales (Billion Kilowatthours)	3,294	3,926	3,795	3,632	3,688	3,625
Gross Domestic Product (Billion 1996 Dollars)	8,876	11,605	11,605	11,513	11,605	11,562
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	2.86	2.54	2.84	2.26	2.77
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.2	5.9	7.5	6.5	7.2
Emissions[a]						
CO_2 (Million Metric Tons Carbon Equivalent)[b]	1,511	1,750	1,711	1,547	1,569	1,493
SO_2 (Million Tons)	13.5	10.1	10.1	3.5	10.1	3.6
NO_x (Million Tons)	5.4	4.3	4.2	1.8	3.7	1.8
Hg (Tons)	43.4	45.4	44.9	4.3	40.4	4.3
Allowance Prices						
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	0	72	50	58
SO_2 (1999 Dollars per Ton)	0	177	175	4	116	46
NO_x (1999 Dollars per Ton)[c]	0	0	0	1,210	0	1,232
Hg (Million 1999 Dollars per Ton)	0	0	0	640	0	635

[a] CO_2 emissions are from all energy sectors. Other emissions are from electricity generators, excluding cogenerators.
[b] CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
[c] Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

higher demand by electricity generators that are subject to the emissions limits. Natural gas demand is also projected to be higher for commercial and industrial cogeneration in all cases except the *CEF-JL* advanced case, which is the exception because of the $50 per ton carbon fee assumed in that case even without emissions limits. As a result of higher projected natural gas demand, natural gas prices are projected to be higher in all four cases when the emissions limits are imposed.

Because the *CEF-JL* advanced case includes a $50 per ton carbon fee and also include a policy to reduce particulate emissions, coal consumption is sharply reduced in that case and electricity prices are higher relative to the reference case, even without the emissions limits. Because of the $50 per ton carbon fee, imposing emissions limits only results in a small additional reduction in total energy demand, 1.0 percent in 2020, in the *CEF-JL* advanced case with emissions limits.

The assumed emissions limits are expected to have measurable short-term impacts on the economy when the limits are fully imposed in 2007. However, the impact is significantly reduced even by 2010, as the economy adjusts to higher energy prices. In all cases except the reference case, the macroeconomic impacts of the emissions limits are essentially eliminated by 2020.

1. Introduction

Background

Request for Analysis

The analysis in this report was undertaken at the request of Senators James M. Jeffords (I-VT) and Joseph I. Lieberman (D-CT), subsequent to the report *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide*, published by the Energy Information Administration (EIA) in December 2000.[1] The analysis in the December 2000 report was expanded in the report *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard*, published by EIA in July 2001.[2] In the July 2001 report, EIA analyzed the impacts of a number of different limits for sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and mercury (Hg) emissions from electricity generators, which varied by level and start year, and a renewable portfolio standard. The analysis was conducted relative to the reference case of the *Annual Energy Outlook 2001* (*AEO2001*),[3] published in December 2000, using EIA's National Energy Modeling System (NEMS).[4]

For this analysis, Senators Jeffords and Lieberman requested that EIA consider the impacts of technology improvements and other market-based opportunities on the costs of emissions reductions from electricity generators. Using 2002 as a start date for emissions reductions, the request specifies that by 2007 NO_x emissions from electricity generators are to be reduced to 75 percent below 1997 levels, SO_2 emissions to 75 percent below the full implementation of the Phase II requirements under Title IV of the Clean Air Act Amendments of 1990 (CAAA90), Hg emissions to 90 percent below 1999 levels, and CO_2 emissions to 1990 levels (Figure 1). These emissions limits are applied to all electricity generators, excluding cogenerators, which produce both electricity and useful thermal output and account for less than 10 percent of total generation. (Throughout this report cogenerators are excluded when reference to electricity generators is made.)

The impacts of these limits are analyzed against four different cases with varying levels of energy demand: the reference case from *AEO2001*, a case combining the high technology assumptions for end-use demand, supply, and generating technologies from *AEO2001*, and the moderate and advanced policy cases from *Scenarios for a Clean Energy Future* (*CEF*), a publication of an interlaboratory working group, published in November 2000 (Table 1).[5] In general, the emissions limits are achieved through a combination of reductions in energy demand, shifts from coal-fired electricity generation to nuclear, natural gas, and renewable generation, and additional emissions control equipment. Within the time frame of the emissions limits, economical technologies to capture and sequester CO_2 are unlikely. Sequestration technologies are included in the analysis but do not penetrate because they are not economical.

This chapter summarizes EIA's previous analysis of multi-emission reduction strategies for electricity generator emissions and the reference case projections of *AEO2001*, describes the methodology of NEMS, and summarizes *CEF*. Chapter 2 presents the impacts and costs of the emissions limits for the reference and advanced technology cases. Chapter 3 presents the impacts and costs for the cases incorporating the moderate and advanced policies from *CEF*. The letter of request is provided in Appendix A, and detailed tables of assumptions incorporated for the industrial sector are provided in Appendix B. Appendix C presents the energy market results for the reference and advanced

[1]Energy Information Administration, *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide*, SR/OIAF/2000-05 (Washington, DC, December 2000), web site www.eia.doe.gov/oiaf/servicerpt/powerplants/index.html.

[2]Energy Information Administration, *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard*, SR/OIAF/2001-03 (Washington, DC, July 2001), web site www.eia.doe.gov/oiaf/servicerpt/epp/index.html.

[3]Energy Information Administration, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001) (Washington, DC, December 2000), web site www.eia.doe.gov/oiaf/aeo/index.html.

[4]Energy Information Administration, *The National Energy Modeling System: An Overview 2000*, DOE/EIA-0581(2000) (Washington, DC, March 2000), web site www.eia.doe.gov/oiaf/aeo/overview/index.html.

[5]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), web site www.ornl.gov/ORNL/Energy_Eff/CEFOnep.pdf.

technology cases, and Appendix D presents the results for the cases based on *CEF*.

Multi-Emission Reduction Policies

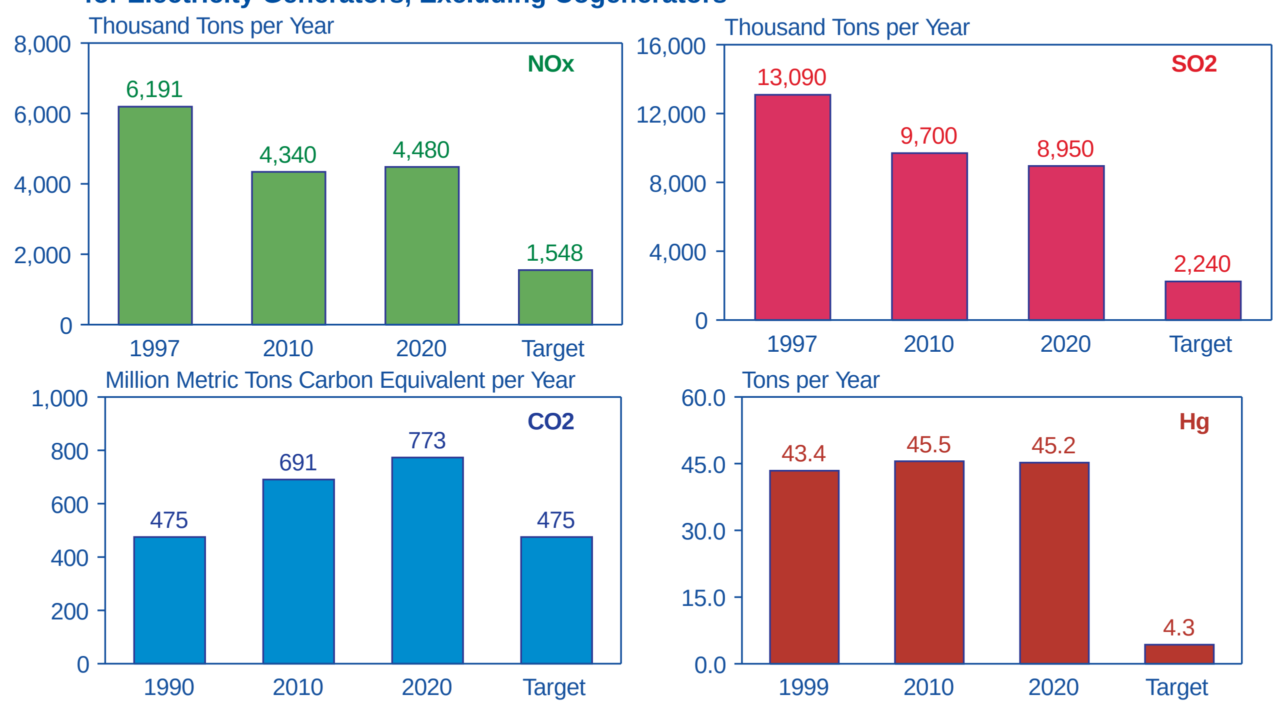
Currently, different environmental issues are being addressed through separate regulatory programs, many of which are undergoing modification. To control acid rain formation, CAAA90 required operators of electric power plants to reduce emissions of SO_2 and NO_x. Phase II of the SO_2 reduction program—reducing allowable SO_2 emissions to an annual national cap of 8.95 million tons—became effective on January 1, 2000. More stringent NO_x emissions reductions are required under various Federal and State laws taking effect from 1997 through 2004. States are also beginning efforts to address visibility problems (regional haze) in national parks and wilderness areas throughout the country. Because electric power plant emissions of SO_2 and NO_x contribute to the formation of regional haze, States could require that those emissions be reduced to improve visibility in some areas. In the near future, it is expected that new national ambient air quality standards for ground-level ozone and fine particulates may necessitate additional reductions in NO_x and SO_2.

To reduce ozone formation, the U.S. Environmental Protection Agency (EPA) has promulgated a multi-State summer season cap on power plant NO_x emissions that will take effect in 2004. Emissions of fine particles (less than 2.5 microns in diameter), their impacts on health, and the level of reductions that might be required are currently being studied. Fine particles are associated with power plant emissions of NO_x and SO_2, and further reductions in NO_x and SO_2 emissions could be required by as early as 2007 in order to reduce emissions of fine particles. In addition, the EPA decided in December 2000 that Hg emissions must be reduced. Furthermore, if the United States decides to reduce its emissions of greenhouse gases, it is likely that energy-related CO_2 emissions will have to be reduced as a part of that program (see box on page 4).

Because the timing and levels of emission reduction requirements being considered are uncertain, compliance planning is complicated. It can take several years to design, license, and construct new electric power plants and emission control equipment, which may then be in operation for 30 years or more. As a result, power plant operators must look into the future to evaluate the economics of new investment decisions.

The potential for new emissions standards with different timetables adds considerable uncertainty to investment planning decisions. An option that looks attractive to meet one set of SO_2 and NO_x standards may not be attractive if further reductions are required in a few years. Similarly, economical options for reducing SO_2 and NO_x today may not be the optimal choice in the future if Hg and CO_2 emissions must also be reduced. Further complicating planning, some investments capture multiple emissions simultaneously, such as advanced flue gas desulfurization equipment that

Figure 1. Historical Emissions, Reference Case Projections for 2010 and 2020, and Target Caps for Electricity Generators, Excluding Cogenerators



Sources: **History:** Energy Information Administration, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). **Projections:** National Energy Modeling System, run AEO2001.D101600A.

reduces SO_2 and Hg, making such investments more attractive under some circumstances. As a result, power plant owners currently are wary of making investments that may prove unwise a few years hence.

In both the previous and current Congresses, legislation has been proposed that would require simultaneous reductions of multiple emissions. Several bills were introduced in the 106th Congress to address these issues: S. 1369, the Clean Energy Act of 1999, introduced by Senator Jeffords; S. 1949, the Clean Power Plant and Modernization Act of 1999, introduced by Senator Leahy; H.R. 2900, the Clean Smokestacks Act of 1999, introduced by Congressman Waxman; H.R. 2645, the Consumer, Worker, and Environmental Protection Act of 1999, introduced by Congressman Kucinich; and H.R. 2980, the Clean Power Plant Act of 1999, introduced by Congressman Allen.

Additional bills introduced in the 107th Congress with similar goals include S. 556, the Clean Power Act of 2001, introduced by Senator Jeffords; H.R. 1256, the Clean

Table 1. Description of the Analysis Cases

Case Name	Description	Emissions Limits
CEF business-as-usual	Reference case in the *CEF* report. Prepared using a revision of the *Annual Energy Outlook 1999* version of the National Energy Modeling System, which is known as *CEF*-NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
CEF moderate	Case in the *CEF* report adding the moderate *CEF* policies to the *CEF* business-as-usual case. Prepared using *CEF*-NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
CEF advanced	Case in the *CEF* report adding the advanced *CEF* policies to the *CEF* business-as-usual case. Prepared using *CEF*-NEMS.	Reduces SO_2 emissions from electricity generators in steps between 2010 and 2020 to 4.48 million tons to simulate a particulate reduction policy. Includes a domestic CO_2 trading system across all energy sectors, which is assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent.
Reference	EIA reference case for this analysis, incorporating some revisions to the *Annual Energy Outlook 2001* reference case. Prepared using NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
Reference with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above reference case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements.
Advanced technology	EIA case incorporating the *Annual Energy Outlook 2001* high technology assumptions for end-use demand, generation, and fossil fuel supply technologies to the reference case. Prepared using NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
Advanced technology with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above advanced technology case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements.
CEF-JL moderate	EIA case incorporating the moderate *CEF* policies in the reference case. Prepared using NEMS.	Includes limits for SO_2 and NO_x under CAAA90.
CEF-JL moderate with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above *CEF-JL* moderate case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements.
CEF-JL advanced	EIA case incorporating the advanced *CEF* policies in the reference case. Prepared using NEMS.	Reduces SO_2 emissions from electricity generators in steps between 2010 and 2020 to 4.48 million tons to simulate a particulate reduction policy. Includes a domestic CO_2 trading system across all energy sectors, which is assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent.
CEF-JL advanced with emissions limits	EIA case adding the emissions limits specified in the request for analysis to the above *CEF-JL* advanced case. Prepared using NEMS.	Between 2002 and 2007, reduces NO_x emissions from electricity generators to 75 percent below 1997 levels, Hg emissions to 90 percent below 1999 levels, CO_2 emissions to 1990 levels, and SO_2 emissions to 75 percent below the CAAA90 requirements. Includes a domestic CO_2 trading system across all energy sectors, which is assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Smokestacks Act of 2001, introduced by Congressman Waxman; and H.R. 1335, the Clean Power Plant Act of 2001, introduced by Congressman Allen. Each of the bills introduced in the 106th and 107th Congresses contains provisions to reduce power plant emissions of NO_x, SO_2, CO_2, and Hg over the next decade. The bills use different approaches—traditional technology-specific emission standards, generation performance standards, explicit emission caps with trading programs, or combinations of the three—but all call for significant reductions. In addition, the Bush Administration's National Energy Policy recommends the establishment of "mandatory reduction targets for emissions of three main pollutants: sulfur dioxide, nitrogen oxides and mercury."[6] While differences exist on what the appropriate emissions limits should be and how the

Representation of New Environmental Rules and Regulations

The reference case for this analysis excludes several potential environmental actions, such as new regulations affecting regional haze, for which States are developing implementation plans; the implementation of new National Ambient Air Quality Standards (NAAQS) for fine particulates, which is still being reviewed by the U.S. Environmental Protection Agency (EPA) and the courts; and the possible ratification of the Kyoto Protocol. In addition, no effort is made to predict the outcome of ongoing studies of the need to reduce power plant Hg emissions[a] or the resolution of lawsuits against the owners of coal-fired power plants accused of violating the Clean Air Act (CAA).

In June 1999, the EPA issued regulations to improve visibility (reduce regional haze) in 156 national parks and wilderness areas across the United States. It is expected that these rules will have an effect on power plants, but the degree to which they will be affected is not known. Power plant emissions of SO_2 and NO_x, which contribute to the formation of regional haze, may have to be reduced to improve visibility in some areas. The regulations call for States to establish goals and design plans for improving the visibility in affected areas; however, State implementation plans (SIPs) are not required until 2004 or later and therefore are not represented in this analysis, because they have not yet been promulgated.

The revised NAAQS, issued by the EPA in 1997, created a standard for fine particles smaller than 2.5 micrometers in diameter ($PM_{2.5}$). As with regional haze, power plant emissions of SO_2 and NO_x are a component of fine particulate emissions. At the request of the President (memorandum July 16, 1997), the EPA is now reviewing scientific data on fine particulate emissions to determine whether to revise or maintain the standard. The review is expected to be completed in 2002. If the standard is maintained, States will be required to submit plans to comply by 2005.

In December 1997, 160 countries met to negotiate binding limitations on greenhouse gas emissions for the developed nations. CO_2 emissions from fossil-fired power plants are a key component of greenhouse gas emissions. The developed nations agreed to limit their greenhouse gas emissions to 5 percent below the levels emitted in 1990, on average, between 2008 and 2012. The target for the United States is 7 percent below the 1990 emission level for all greenhouse gases. Reductions would be required if the U.S. Senate ratified the protocol. However, the President has indicated that the United States will not support the approach called for in the Protocol. At this time, while 39 countries have ratified the protocol, only one Annex I (developed) country, Romania, has ratified the agreement. In addition, various elements of the Protocol are still under negotiation.

The Clean Air Act Amendments of 1990 (CAAA90), Section 112(n)(1)(A), required that the EPA prepare a study of hazardous air emissions from steam generating units. The report was submitted to Congress on February 24, 1998. Its key finding was that Hg emissions from coal-fired power plants posed the greatest potential for harm. The EPA is now collecting and analyzing data on Hg emissions from specific power plants. The data, together with continuing studies on the health effects of Hg, will be used to determine the extent to which emissions need to be reduced. The EPA will be developing proposed regulations for reducing Hg emissions over the next 3 years.

On November 3, 1999, the Justice Department, on behalf of the EPA, filed suit against seven electric utility companies, accusing them of violating CAAA90 by not installing state-of-the-art emissions control equipment on their power plants when major modifications were made. CAAA90 requires that when major modifications are made to older power plants they must also be upgraded to comply with the emissions standards for new power plants. The EPA is arguing that the seven companies and the Tennessee Valley Authority made major modifications to 32 power plants but did not add the required emissions control equipment. The continued pursuit and outcome of these cases is uncertain at this time.

[a]On December 15, 2000, the EPA announced that Hg emissions need to be reduced, and that regulations will be issued by 2004.

[6]President George W. Bush, *National Energy Policy: Report of the National Energy Policy Development Group* (Washington, DC, May 2001).

program should be implemented, it is generally agreed that a more coordinated emission reduction policy is worth pursuing.

The analysis presented in this report is an examination of the impacts on energy markets that might result from steps taken by power suppliers to meet the emission limits specified in the request, given varying levels of energy demand. The potential benefits of reduced emissions—such as those that might be associated with reduced health care costs—are not addressed, because EIA does not have expertise in this area. It is important to realize that there are numerous policy instruments available for reducing emissions, i.e., technology standards, percentage reduction requirements, emission taxes, no-cost emission allowance allocation with cap and trade, emission allowance auction with cap and trade, and annual generation performance standard emission allowance allocation with cap and trade. Each of these approaches has different implications for the resource cost, price, and economic impacts of the emission reduction program. In general, an efficient cap and

Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard

The EIA report *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, Mercury and a Renewable Portfolio Standard* was released in July 2001, in response to a request from the Subcommittee on Energy Policy, Natural Resources, and Regulatory Affairs of the U.S. House of Representatives Committee on Government Reform. The Subcommittee requested that EIA analyze the impacts of coordinated efforts to reduce power plant emissions of NO_x, SO_2, CO_2, and Hg together with a 20-percent renewable portfolio standard. The analysis was prepared in two parts. The first part, which analyzed NO_x, SO_2, and CO_2, was released in December 2000. The report released in July 2001 extended the analysis to include the impacts of Hg emission reductions and the renewable portfolio standard.

The July 2001 EIA report examined the impact of the proposed emissions requirements on fuel use by electricity generators, capacity expansion and retirement decisions, electricity prices, and consumer demand for electricity. It also included discussion of the price and supply impacts on coal, natural gas, and renewable technologies. As requested by the Subcommittee, cases were prepared to examine the impacts of Hg emissions targets and a renewable portfolio standard separately, as well as when all of the emissions limits were combined with the standard. The “integrated cases” included cases reducing CO_2 emissions to 1990 levels and to 7 percent below 1990 levels. The key findings of the analysis included the following:

- Reducing NO_x and SO_2 emissions in the electricity generation sector to 75 percent below their 1997 levels is projected to lead to the installation of a large amount of pollution control equipment with little change in fuel use for electricity generation. The power suppliers are projected to incur significant expenditures, but electricity prices are expected to be only slightly higher than the reference case level.
- Reducing Hg emissions by electricity generators to 90 percent below their 1997 level is projected to lead to the installation of a large amount of pollution-control equipment. The cost and price impacts of reducing the Hg emissions are projected to be larger than those of reducing NO_x or SO_2 emissions.
- There is considerable uncertainty regarding the cost and performance of Hg control technologies due to the lack of sufficient full-scale tests on existing generating units.
- The projected impacts of a limit on CO_2 emissions from electricity generators that is 7 percent below 1990 levels dominate the impacts of limits on other emissions. The key compliance strategy in the cases that include CO_2 emissions reductions is expected to be a large shift from coal to natural gas and, to a lesser extent, renewables and nuclear power as fewer existing nuclear plants are retired.[a] Consumers are also expected to reduce their use of electricity in response to higher electricity prices.
- The imposition of a 20-percent renewable portfolio standard is projected to cause electricity generators to moderate the growth in their use of natural gas and, to a lesser extent, coal. Biomass, wind, and geothermal resources are projected to provide most of the required increase in renewable generation.
- Combining a 20-percent renewable portfolio standard with limits on NO_x (75 percent below 1997), SO_2 (75 percent below 1997), Hg (90 percent below 1997), and CO_2 emissions (7 percent below 1990) is projected to reduce the shift to natural gas as a fuel for electricity generation and increase the use of renewable fuels.

[a]In accordance with the Subcommittee request, this study assumed that there would be no construction of new nuclear plants.

trade program is expected to lead to the lowest resource cost of compliance.[7]

The specific design of the cases, in terms of the timing, emissions limits, and technology assumptions, is important and should be kept in mind when the results are reviewed. Unlike the previous EIA reports on multi-emissions limits, all the cases specified in this request require the same timing and levels for the four emissions. The differences among the cases are additional assumptions, policies, and programs that encourage more rapid technology development and the adoption and penetration of more energy-efficient and renewable energy technologies. All the analysis cases assume that market participants—power suppliers, consumers, and coal, natural gas, and renewable fuel suppliers—would

Reducing NO_x and Hg Emissions

Considerable uncertainty exists about the ability of various types of emissions control equipment to remove Hg and, to a lesser extent, NO_x. Many factors affect the level of Hg emissions from a particular power plant, including the Hg content (by speciation—elemental Hg versus various Hg-containing compounds), chlorine content, and other chemical constituents of the coal used; the rank of the coal (i.e., bituminous or subbituminous); the boiler temperature and firing type and the flue gas temperature; and the types of existing control equipment for NO_x, SO_2, and particulates. In recent years data collection and analysis efforts have focused on these factors so that better estimates of current power sector Hg emissions could be developed; however, substantial uncertainty remains. As additional tests are performed, factors currently unaccounted for may turn out to be important.

Data collected by the Environmental Protection Agency in 1999 showed considerable variation in the content of Hg in the coal used by power plants and in the amount of Hg that was removed by the existing equipment at those power plants. On average the sample data show that the Hg content of coal shipped in 1999 was 7.3 pounds per trillion British thermal units (Btu), or approximately 0.2 pounds of Hg per thousand short tons of coal; however, there was considerable variation among coals from different seams, even within a given coal supply region. For example, the 1999 data indicated that coal shipments from the Pittsburgh seam in Northern Appalachia had an average Hg content of 8.2 pounds per trillion Btu, whereas shipments from the Upper Freeport seam averaged 16.4 pounds Hg per trillion Btu.

Even within the same coal seam, the tested shipment data show considerable variation in Hg content. For example, although the average Hg content for the Pittsburgh seam was 8.2 pounds per trillion Btu, the minimum for shipments from that seam was 0.1 pounds per trillion Btu and the maximum was 73.1 pounds per trillion Btu. In statistical terms, the standard deviation for Hg content at the Pittsburgh seam is 4.04, indicating that most samples should have Hg contents between 0.1 and 16.3 pounds of Hg per trillion Btu.

The Hg removal rates for the various coal plant configurations also showed significant variation. The 1999 data show that, on average, a cold-side electrostatic precipitator (CSE)—a particulate removal device—removes 31 percent of the Hg that passes through it. However, the variation among plants with CSEs was large, ranging between 0 percent and 87 percent removal. The situation was similar for facilities with fabric filters—another type of particulate removal device. On average they removed 69 percent of the Hg passing through them, but, after excluding plants that actually reported increases in Hg after passing flue gas through the fabric filter, the removal rate ranged between 54 percent and nearly 100 percent.

In addition, there is very little information on the impact of new NO_x control devices—selective noncatalytic reduction (SNCR) and selective catalytic reduction (SCR) equipment—on Hg emissions. Although many plant owners plan to add them in the near future, only a few are using them now. With respect to NO_x, SCRs are assumed to reduce emissions by 75 to 80 percent on average; however, because so few plants have SCRs today, the true cost and performance of the technology are not known at this time. With respect to Hg, this study assumes that, when combined with an SO_2 scrubber, an SCR enhances Hg removal with an emissions modification factor of 0.65 (increases Hg removal by 35 percent); however, no additional removal is assumed for plant configurations that have an SCR but do not have an SO_2 scrubber. Some pilot-scale tests suggest that SCRs would increase Hg removal for some system configurations, but the magnitude of the impact is not known at this time.

[7]For an analysis of the potential impacts of different emission allowance approaches, see D. Burtraw, K. Palmer, R. Bharvirkar, and A. Paul, *The Effect of Allowance Allocation on the Cost of Carbon Emission Trading* (Washington, DC: Resources for the Future, August 2001); and C. Fischer, *Rebating Environmental Policy Revenues: Output-Based Allocations and Tradable Performance Standards* (Washington, DC: Resources for the Future, July 2001). For an analysis of the impacts of a generation performance standard, see Energy Information Administration, *Power Plant Emissions Reductions Using a Generation Performance Standard* (Washington, DC, May 2001), web site www.eia.doe.gov/oiaf/servicerpt/gps/gpsstudy.html.

become aware of impending emission limits before their start dates and would begin to take action accordingly. If it had been assumed that market participants would not anticipate the emission limits, the results would be different. In an earlier EIA study that looked at alternative program start dates for imposing a CO_2 emissions limit, an earlier start date and longer phase-in period were found to smooth the transition of the economy.[8]

This study is not intended to be an analysis of any of the specific congressional bills that have been proposed, and the impacts estimated here should not be considered as representing the consequences of specific legislative proposals. All the congressional proposals include provisions other than the emissions limits studied in this analysis, and several would use different policy instruments to meet the emissions limits. Moreover, some of the actions projected to be taken to meet the emissions limits in this analysis may eventually be required as a result of ongoing environmental programs whose requirements currently are not fully specified. The purpose of this report is to respond to the specific request by Senators Jeffords and Lieberman.

The National Energy Modeling System and the *Annual Energy Outlook 2001*

The National Energy Modeling System

The projections in this report were developed using NEMS, an energy-economy modeling system of U.S. energy markets, which is designed, implemented, and maintained by EIA and used annually to produce the projections in EIA's *Annual Energy Outlook*. NEMS is also used to analyze the effects of existing and proposed laws, regulations, and standards related to energy production and use; the impacts of new and advanced energy technologies; the savings from higher energy efficiency; the impacts of energy tax policy on the U.S. economy and energy system; and the impacts of environmental policies. Special analyses of these and other topics are performed at the request of the U.S. Congress, other offices in the U.S. Department of Energy (DOE), and other government agencies.

In NEMS, the production, imports, conversion, consumption, and prices of energy are projected for each year through 2020, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. NEMS is a fully integrated framework, capturing the interactions of energy supply, demand, and prices across all fuels and all sectors of U.S. energy markets.

Within NEMS, four end-use demand modules represent energy consumption in the residential, commercial, industrial, and transportation sectors, subject to fuel prices, macroeconomic factors, and the characteristics of energy-using technologies in those sectors. The fuel supply and conversion modules represent the domestic production, imports, transportation, and conversion processes to meet the domestic and export demand for coal, petroleum products, natural gas, and electricity, accounting for resource base characteristics, industry infrastructure and technology, and world market conditions. The modules of NEMS interact to solve for the economic supply and demand balance for each fuel.

In order to capture regional differences in energy consumption patterns and resource availability, NEMS is a regional model. The end-use demand for energy is represented for each of the nine Census divisions. The supply and conversion modules use the North American Electric Reliability Council regions and subregions for electricity generation; aggregations of the Petroleum Administration for Defense Districts for refineries; and production regions specific to oil, natural gas, and coal supply and distribution.

NEMS incorporates interactions between the energy system and the economy and between domestic and world oil markets. Key macroeconomic variables, including the gross domestic product (GDP), disposable personal income, industrial output, housing starts, employment, and interest rates, drive energy consumption and investment decisions. In turn, changes in energy prices and energy activity affect economic activity, a feedback captured within NEMS. Also, an international energy module in NEMS represents world oil prices, production, and demand and the interactions between the domestic and world oil markets. Within this module, world oil prices and supplies respond to changes in U.S. demand and production.

A key feature of NEMS is the representation of technology and its improvement over time. The residential, commercial, transportation, electricity generation, and refining sectors of NEMS include explicit treatments of individual technologies and their characteristics, such as capital cost, operating cost, date of commercial availability, efficiency, and other characteristics specific to the sector. In each of these sectors, equipment choices are made for individual technologies as new equipment is needed to meet growing demand for energy services or to replace retired equipment. In addition, in the electricity generation sector, fossil-fired and nuclear generating units can be retired before the end of their useful lives if

[8]Energy Information Administration, *Analysis of the Impacts of an Early Start for Compliance with the Kyoto Protocol*, SR/OIAF/99-02 (Washington, DC, July 1999), web site www.eia.doe.gov/oiaf/kyoto3/kyoto3rpt.html.

it is more economical to bring on a replacement unit than to continue to operate the existing unit. Also, for new generating technologies, the electricity sector accounts for technological optimism in the capital costs of first-of-a-kind plants and for a decline in the costs as experience with the technologies is gained both domestically and internationally. Similar cost declines occur for the new end-use technologies.

In the other sectors—industrial, oil and gas supply, and coal supply—the treatment of technologies is somewhat more limited due to limitations on the availability of data for individual technologies. In the industrial sector, technology improvement for the major processing steps of the energy-intensive industries is represented by technology possibility curves of efficiency improvements over time. In the oil and gas supply sector, technology progress for exploration and production activities is represented by trend-based improvements in success rates, finding rates, and costs. Productivity improvements over time represent technological progress in coal production.

Because of the detailed representation of capital stock vintaging and technology characteristics, NEMS captures the most significant factors that influence the turnover of energy-using and producing equipment and the choice of new technologies. New, more advanced technologies for buildings and equipment are generally characterized by the technology costs, performance, and availability, existing standards, and energy prices. Equipment that does not meet efficiency standards is not available as a choice. In all sectors, technology improvement occurs even in a reference case, because new, more efficient technology will be adopted as the demand for energy services increases and existing buildings and equipment are replaced. The characteristics of the technologies include initial dates of commercial availability of more advanced technologies as well as changes in efficiencies and costs that are assumed to occur in the future.

Past improvements in energy efficiency have resulted in part from efficiency standards that are included in the analysis; future efficiency standards assumed are those approved standards with specified efficiency levels. New or tightened efficiency standards could reduce the demand for energy, but stock turnover would still limit the speed of penetration. Standards have also been suggested to encourage the use of renewable fuels for electricity generation; however, proposed and possible future standards, legislation, and programs are not included in the analysis.

Although more efficient technologies may reduce energy consumption and energy expenditures, they are typically more expensive to purchase. Even if the full life-cycle cost of purchasing and operating a new, more efficient appliance is less than the life-cycle cost of a less efficient appliance, many consumers appear to be more concerned with the initial cost of an appliance when making the purchase. Higher energy prices may accelerate the adoption of more efficient technologies; however, higher purchase costs for more efficient technologies tend to slow their adoption. Hurdle rates represent this tendency of consumers to consider the first costs of new equipment.

Although prices play a role in consumers' decisions on energy-consuming equipment, there are other factors that come into play. Consumers tend to make decisions based on a number of personal preferences and lifestyle choices, in which energy prices may be only a part of the decisionmaking process. Preferences for larger televisions or higher horsepower vehicles are examples of factors that may outweigh energy costs. As another example, in the residential sector, home rental instead of purchase and frequent moving tend to lower the incentive to invest in more energy-efficient equipment. Information also has a major role in consumer decisions and will likely continue to do so in the adoption of new, more advanced technologies. Particularly when a more efficient or alternatively fueled technology carries a significantly higher cost or has different operational characteristics than more conventional technologies, information on the benefits of the new technology will be key to its adoption and penetration. Ultimately, the success of a given technology will depend not on the behavior of the marginal consumer, who may be particularly cost-conscious or innovative, but on the behavior of the average consumer, whose decision rests on a number of considerations.

Technology improvements, even when adopted in the market, may not necessarily lead to reductions in energy demand. In the transportation sector, for example, the use of more advanced technologies that could improve vehicle efficiency has been offset by increasing demand for larger and higher horsepower vehicles. To the extent that energy prices are a factor in consumer decisions, efficiency improvements may also increase energy demand. Efficiency gains may lower the cost of driving or operating other equipment, perhaps encouraging more travel, larger homes, and purchases of more equipment and increasing the demand for energy services.

Annual Energy Outlook 2001

In accordance with the request from Senators Jeffords and Lieberman, this study is based on the reference case of *AEO2001*. Because EIA's reference case projections are required to be policy-neutral, the *AEO2001* projections generally assume that all Federal, State, and local law, regulations, policies, and standards in effect as of July 1, 2000, will remain unchanged through 2020. Potential impacts of pending or proposed legislation, proposed standards, legislation or regulations for which all specifics were not yet defined, or sections of existing legislation for which funds had not been appropriated prior to the preparation of *AEO2001* are not included in the projections. As a result, new regulations for diesel fuel and the new equipment efficiency standards announced in January 2001 are not included in the *AEO2001* projections. *AEO2001* assumes the continuation of the ethanol tax incentive through 2020. *AEO2001* also assumes that State taxes on gasoline, diesel, jet fuel, methanol, and ethanol will increase with inflation and that Federal taxes on those fuels will continue at 1999 levels in nominal terms. Although these taxes and tax incentives include clauses that limit their duration, they have been extended historically, and *AEO2001* assumes their continuation throughout the forecast. In general, the *AEO2001* projections include the most current data available as of July 31, 2000.

In the electricity generation sector, *AEO2001* includes the requirements of the CAAA90 to reduce SO_2 emissions to 8.95 million tons by 2010 and to meet new boiler standards for NO_x. *AEO2001* also represents the provisions of the NO_x State Implementation Plan call in the 19 States where NO_x caps have been finalized. Those NO_x constraints begin in 2004 and are for the summer season only. Regulations that are not in place or are without specific guidelines are not included in *AEO2001*. In the electricity sector, these include new regulations for regional haze, which may affect electricity generators, but for which the State implementation plans are not required until 2004 or later, and new National Ambient Air Quality Standards for particulates, which are still being reviewed by the EPA and the courts. In addition, Hg emission reductions that may be required in the future by the EPA, which has announced that regulations will be issued by 2004, are not incorporated because they have not been finalized.

AEO2001 projects that the U.S. economy, measured by real GDP, will grow at an average annual rate of 3.0 percent from 1999 through 2020. In *AEO2001*, both world oil prices and domestic natural gas prices are projected to decline over the next several years from their current high levels before gradually increasing in response to rising demand. Due to continued technological improvement in the production of oil and the expansion of production capability worldwide, the world oil price is expected to reach $22.41 per barrel in 2020 in real, inflation-adjusted 1999 dollars. With technological advances in the exploration and production of natural gas, the average wellhead price is projected to be $3.13 per thousand cubic feet in 2020. The average price of coal declines throughout the projection period due to increasing productivity in coal production and the expansion of production from lower-cost western sources.

The *AEO2001* projections assume a transition to full competitive pricing of electricity in States with specific deregulation plans—California, New York, New England, the Mid-Atlantic States, Illinois, Texas, Oklahoma, Michigan, Ohio, Arizona, New Mexico, and West Virginia. Other States are assumed to continue cost-of-service electricity pricing. A transition from regulated to competitive prices over a 10-year period from the beginning of restructuring in each region, and implementation of the provisions of California legislation regarding price caps, are assumed. Increased competition in electricity markets is also represented through assumed changes in the financial structure of the industry and efficiency and operating improvements that reduce operating and maintenance, administrative, and other costs. With these assumptions and declining coal prices, real average delivered electricity prices are projected to decline generally at an average annual rate of 0.5 percent between 1999 and 2020.

Electricity demand is projected to increase at an average annual rate of 1.8 percent between 1999 and 2020, most rapidly in the residential and commercial sectors due to growth for computers, office equipment, and other electrical equipment and appliances. Electricity generation fueled by natural gas and coal is projected to increase through 2020 to meet growing demand for electricity and to offset the projected retirement of existing nuclear and fossil units. Excluding cogeneration, the share of natural gas generation is projected to increase from 11 percent in 1999 to 33 percent in 2020, and the coal share is projected to decline from 54 percent to 47 percent, because electricity industry restructuring favors the less capital-intensive and more efficient natural gas generation technologies. Retirements of nuclear plants in the forecast are based on the costs of continuing to operate existing plants compared with the cost of new generating capacity. Of the 97 gigawatts of nuclear capacity available in 1999, 26 gigawatts is projected to be retired by 2020, and no new plants are expected to be constructed by 2020. The use of renewable energy technologies for electricity generation is projected to grow slowly because of the relatively low costs of fossil-fired generation and because electricity restructuring favors less capital-intensive natural gas technologies over coal and baseload renewable technologies.

With decreases or moderate increases in the prices of energy and continued economic growth, total energy consumption in *AEO2001* is projected to increase at an average rate of 1.3 percent per year through 2020, reaching 127 quadrillion British thermal units (Btu). Consumption in all end-use sectors grows in the projections; however, demand in the transportation sector increases most rapidly, reflecting increased travel and slow improvement in vehicle efficiency. Primary energy intensity, measured as energy use per dollar of real

GDP, declines in the projections at an average annual rate of 1.6 percent. This rate is less than the 2.3-percent decline in energy intensity experienced between 1970 and 1986, when rapid price increases and a shift to less energy-intensive industries led to rapid improvements in energy intensity. However, the intensity decline is more rapid than the average decline in the late 1980s and 1990s, reflecting efficiency improvements and continued structural shifts in the economy, which reduce the role of energy-intensive manufacturing industries.

CO_2 emissions from energy combustion are projected to increase at an average rate of 1.4 percent per year in *AEO2001*, growing from 1,511 to 2,041 million metric tons carbon equivalent between 1999 and 2020. Continuing economic growth and increasing demand for energy services lead to the continued projected growth in emissions. The slow growth of renewable technologies and the decline of electricity generation from nuclear power plants also contribute to emissions increases.

Revisions to the *AEO2001* Reference Case

In accordance with the request, this study is based on the version of NEMS used in *AEO2001*; however, a few updates have been incorporated for this study.

Short-Term Energy Price Updates

In addition to the *Annual Energy Outlook*, EIA also publishes the *Short-Term Energy Outlook* (*STEO*), a national-level, quarterly projection of U.S. energy supply, demand, and prices. The short-term forecast, which projects energy markets through the end of the following calendar year, is updated monthly. At the time the projections for *AEO2001* were finalized, the short-term results from *AEO2001* were calibrated to the September 2000 *STEO*. World crude oil prices for 2000 are currently estimated at $27.72 per barrel, compared to $28.17 per barrel in *AEO2001*, converted to 2000 dollars. At this time, crude oil prices in 2001 are projected to be similar to those projected in *AEO2001*.

A more significant change has occurred in the projections for natural gas. Converting to nominal dollars, natural gas wellhead prices in *AEO2001* are projected to be about $3.40 and $3.50 per thousand cubic feet in 2000 and 2001, respectively. Natural gas prices have been revised in the version of NEMS used in this study, to about $3.60 and $4.75 per thousand cubic feet in 2000 and 2001, respectively. Natural gas consumption projections in *AEO2001* are 22.0 and 22.7 trillion cubic feet for 2000 and 2001, respectively. Consumption is now estimated at higher levels and is calibrated to the April 2001 *STEO*, resulting in natural gas consumption estimates of 23.0 and 23.3 trillion cubic feet in 2000 and 2001. In the longer term, natural gas wellhead prices are now projected to decline at a slower rate through the next decade than in *AEO2001* and are projected in this study to rise to $3.10 per thousand cubic feet in 2020, similar to the projection of $3.13 per thousand cubic feet in *AEO2001* (both in real 1999 dollars). Total natural gas consumption is projected to be slightly higher, reaching 35.0 trillion cubic feet in 2020, as compared with 34.7 trillion cubic feet in *AEO2001*.

New Equipment Standards

New equipment standards were issued by DOE in January 2001 and revised by the Bush Administration. Because the standards were not finalized when the projections for *AEO2001* were completed, they are not incorporated in the *AEO2001* projections. The new standards have been incorporated in all of the cases in this study, as shown in Table 2. Incorporating these standards reduces the projected demand for electricity and natural gas after 2004, particularly in the residential sector. Projected impacts on commercial energy consumption are small.

Electricity Revisions for Emissions Modeling and Data Updates

AEO2001 incorporates current regulations for emissions of SO_2 and NO_x by electricity generators. However, in order to examine multi-emissions reduction strategies,

Table 2. Appliance Standards Assumed in This Study

Product	Old Standard	New Standard	Effective Date
Residential natural gas water heaters	0.54 EF	0.59 EF	2004
Residential electric water heaters	0.86 EF	0.90 EF	2004
Residential central air conditioners	10 SEER	12 SEER	2006
Residential clothes washers	0.817 MEF	1.04/1.26 MEF	2004/2007
Commercial water-cooled air conditioners	9.3 EER	12.0 EER	2003
Commercial natural gas furnaces	0.80 TE 1.5 percent casing losses	0.80 TE 0.75 percent casing losses	2003
Commercial natural gas water heaters	0.78 TE	0.80 TE	2003

Note: EF is energy factor (Btu out per Btu in); SEER is seasonal energy efficiency ratio (Btu out per watthour in); MEF is modified energy factor (cubic foot per kilowatthour per cycle); EER is energy efficiency ratio (Btu out per watthour in); TE is thermal efficiency (Btu out per Btu in). For commercial cooling equipment, a representative level is shown. Standards for these products vary by size and type of equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

the electricity market module (EMM) of NEMS has been revised to evaluate the impacts of limits on Hg emissions. Potential strategies for reducing Hg emissions include reducing electricity demand, switching to coal types with lower Hg content, installing control equipment, and switching to other fuels, such as natural gas, with little or no Hg content. Changes in electricity demand due to limits on Hg emissions could occur as the costs of compliance result in higher electricity prices. The coal market module (CMM) of NEMS evaluates switching to different coal types in order to reduce Hg emissions. EMM evaluates options to retrofit pollution control equipment and switch fuels in order to achieve Hg emissions limits.

Planning decisions to reduce Hg emission rates at coal-fired plants involve a variety of pollution control equipment. Control devices for SO_2 and NO_x can also affect Hg emissions. Therefore, EMM has been revised since *AEO2001* to specify coal-fired plants according to the type of scrubber (wet, dry, or none) and NO_x controls (low-NO_x burners, selective catalytic reduction, selective noncatalytic reduction, or none). Also, EMM now represents additional equipment, such as spray cooling and fabric filters, that can also reduce Hg emissions with activated carbon injection. This expanded representation of coal-fired plant types considers planning decisions to use control devices for individual or combinations of pollutants.

In addition to constructing plants with emissions control equipment, Hg emissions can also be limited by switching from coal to other fuels with lower emission rates. Within EMM, available plants are dispatched according to their variable costs, which include fuel, operating and maintenance, and emissions costs. The emissions component has been revised to include the Hg allowance cost, i.e., the product of the resulting Hg emissions and the allowance price, in addition to the SO_2 and NO_x allowance costs. Imposing a limit on Hg emissions could revise the dispatch order if a plant with lower fuel costs but higher emissions costs, such as coal, becomes less economic than a plant with higher fuel costs but lower emissions costs, such as natural gas.

CAAA90 currently provides limits on NO_x emission rates for generating units, which depend on the type of boiler. Additional restrictions on NO_x emissions are specified for selected eastern States during the summer months. Since *AEO2001*, EMM has been revised to consider simultaneously a national, annual limit on NO_x emissions that is similar to the “cap and trade” system that limits SO_2 emissions under CAAA90. Because it is assumed that proposed regulations to reduce SO_2 emissions further would incorporate the current trading system, no additional modifications were required.

Updates to available generating capacity have also been incorporated since *AEO2001*. Units previously unreported to EIA that began operation in 1999 and 2000 are now included in the existing capacity. Most of these units use natural gas, which produces fewer emissions than coal- or petroleum-fired capacity. Expected additions of renewable generating capacity in 2000 and 2001 have also been increased, primarily as a result of State mandates, as noted below. Finally, the projected capacity mix incorporates future installations of pollution control equipment and conversions of plants resulting from the settlement of lawsuits between some electricity generators and the EPA.

Revisions to Renewables Data and Assumptions

AEO2001 incorporates near-term projections for known new renewable energy capacity resulting from State mandates and voluntary programs, totaling 5.4 gigawatts by 2020, 3.1 gigawatts of which were from wind power. For this study, estimates of geothermal and wind power have been updated to account for additional announced units and accelerated completions for units that are expected after 2001 in *AEO2001*. As a result, 7.5 gigawatts of additional planned capacity is now included by 2020, 5.1 gigawatts of which is wind capacity.

AEO2001 assumptions include estimates of geothermal resource supply from 51 known geothermal resource areas in the United States; however, it is unlikely that most of the geothermal resources at many new untested sites would be used before 2020. Instead, much smaller installations would be built first, with expansion moving more slowly as additional units prove successful. Furthermore, the *AEO2001* estimates do not account for environmental, market, and other limitations likely to constrain development at many sites. Therefore, for this study, estimates of geothermal resources have been reduced from nearly 47 gigawatts in *AEO2001* to about 28 gigawatts, to provide a more accurate representation of likely development opportunities through 2020. As a result, the cost of geothermal energy is generally higher, and the total quantity of geothermal supply is lower than in *AEO2001*.

Because wind and solar power are intermittent sources of electricity generation, *AEO2001* assumes that no more than 12 percent of the annual generation in any region could be provided by these sources in order to avoid electric power system disturbances. However, based on research done by the National Renewable Energy Laboratory and more recent experience, this assumed limit has been raised to 15 percent for the reference and advanced technology cases but is not a binding limit.[9]

[9] Y.H. Wan and B.K. Parsons, *Factors Relevant to Utility Integration of Intermittent Renewable Technologies*, NREL / TP-463-4953 (Golden, CO: National Renewable Energy Laboratory, August 1993).

As assumed in the *CEF* analysis, the limit is removed in the cases that incorporate the *CEF* policies. The limit would not have been a constraint in the case with the moderate *CEF* policies. In the case incorporating the advanced *CEF* policies, the limit would have been binding for the Upper Great Plains and Rocky Mountain / Southwest regions.

In order to account for short-term supply bottlenecks, the *AEO2001* version of NEMS assumes that, if the national capacity of any renewable generating technology increases by more than 30 percent in one year, the overnight capital cost for that technology would increase by 0.5 percent for each 1-percent capacity increase over 30 percent. Recognizing large worldwide growth for major renewable energy technologies and increased ability to meet demand growth in any country, the threshold has been increased from 30 percent to 50 percent in this study.

Modifications to Coal Production Data and Assumptions

Similar to EMM, revisions have been made to CMM following the *AEO2001* in order to add the capability to evaluate the impacts of Hg emissions limits at U.S. coal-fired power plants. An annual constraint on Hg emissions within CMM and the assignment of an average Hg content for each of the 35 coal supply sources represented in CMM have both been incorporated. The Hg emissions factors in CMM range from a low of 2.04 pounds Hg per trillion Btu for low-sulfur subbituminous coal originating from mines in the Rocky Mountain supply region (Colorado and Utah) to 63.90 pounds Hg per trillion Btu for waste coal originating from sites in Northern Appalachia (Pennsylvania, Ohio, northern West Virginia, and Maryland).[10]

An additional revision made to CMM concerns the size and duration of existing contracts between coal suppliers and electricity generators. In the cases with emissions limits in this analysis, all coal supply contracts are assumed to be phased out by 2003, reflecting the assumption that the accelerated and more stringent emission restrictions would constitute sufficient justification to end contracts under *force majeure* measures.

Scenarios for a Clean Energy Future

Background

CEF was commissioned by DOE's Office of Energy Efficiency and Renewable Energy. The report was prepared by an interlaboratory working group from Argonne National Laboratory, Lawrence Berkeley National Laboratory, the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory.

The purpose of *CEF* was to analyze the impacts of various energy policies and programs that would promote "clean energy technologies," which include reducing the energy intensity of the economy, reducing the CO_2 intensity of the energy used, and integrating the sequestration of CO_2 into energy production and delivery. According to the *CEF* working group, the collection of policies was developed to address key energy issues such as emissions, oil import dependency, and energy and economic efficiency. The policies, which are listed in Chapter 3 of this report, include fiscal incentives, voluntary programs, regulations, and research and development.

CEF analyzed business-as-usual, moderate, and advanced cases. The business-as-usual case assumed current energy policies and programs as of the time *CEF* was prepared, as well as continued technological improvement. It was based on the reference case from the *Annual Energy Outlook 1999* (*AEO99*), the most recent *Annual Energy Outlook* available at the time the *CEF* analysis was initiated.[11] As discussed later, a number of significant modifications have been introduced into NEMS since *AEO99*, including, for example, higher projections of economic growth and electricity demand, which lead to higher energy demand and CO_2 emissions.

The moderate and advanced cases in *CEF* included energy policies and programs to address the energy issues noted above, which can include new programs or extensions of existing programs. In general, the advanced case included additional or extended programs relative to the moderate case. The advanced case also included a domestic CO_2 trading system that was assumed to equilibrate at a permit value of $50 per metric ton carbon equivalent. Additional sensitivities were presented in the report, including cases with higher natural gas and petroleum prices, a shorter life for a proposed renewable portfolio standard, higher costs for renewable technologies, higher costs of advanced fossil-fired generating technologies, no diesel penetration in light-duty vehicles, and a carbon fee of $25 per metric ton carbon equivalent; however, these sensitivities were not the primary results of the study. Most of the sensitivities were designed to analyze some key uncertainties in the analysis as identified by the *CEF* working group.

The *CEF* study followed an earlier report, *Scenarios of U.S. Carbon Reductions*, published by an interlaboratory

[10]U.S. Environmental Protection Agency, Emissions Standards Division, *Information Collection Request for Electric Utility Steam Generating Units, Mercury Emissions Collection Effort* (Research Triangle Park, NC, 1999).

[11]Energy Information Administration, *Annual Energy Outlook 1999*, DOE / EIA-0383(99) (Washington, DC, December 1998), web site www.eia.doe.gov / oiaf / archive / aeo99 / homepage.html.

working group in 1997.[12] The earlier report outlined and analyzed technologies to reduce energy consumption and CO_2 emissions, looking at the individual energy sectors separately. According to the *CEF* authors, *CEF* differed from the prior study by examining the policies and programs that would encourage the adoption and penetration of clean energy technologies. Also, *CEF* included an integrated analysis to assess the impacts of certain changes in one energy sector throughout the energy system—for example, the impact of lower electricity demand on the requirements for electricity generation or the impact of changes in fuel demand on prices. In some cases, *CEF* used a revised version of the *AEO99* version of NEMS, referred to as *CEF*-NEMS, to implement the *CEF* policies directly. In many cases, the policies were analyzed separately, and the results were incorporated in *CEF*-NEMS, using the modeling system as an accounting system to capture the intersectoral impacts.

CEF Revisions to the *AEO99* Reference Case

The *CEF* working group developed a revised version of NEMS, referred to as *CEF*-NEMS, which was based on the NEMS version used for *AEO99*. According to the *CEF* authors, the following revisions were made to the *AEO99* model and assumptions.

In the industrial demand sector, the baseline energy intensities were revised in *CEF* for three of the energy-intensive industries—paper and pulp, cement, and steel—and the rate of improvement in the energy intensity of those three industries was accelerated relative to the rate of improvement assumed in *AEO99*. Since the version of NEMS used for *AEO2001*, as well as *AEO99*, is calibrated to the 1994 Manufacturing Energy Consumption Survey, no changes were made to these baseline data for this study. The retirement rates of equipment in all industries were revised to reflect an assessment of shorter equipment life. These revisions were typically quite small, and some revised rates have been incorporated in NEMS since *AEO99*. As a result of these modifications, projected primary energy consumption for the industrial sector in *CEF* was approximately 1 quadrillion Btu lower in 2020 than the 42.1 quadrillion Btu projected in *AEO99*.

Four sets of changes were made to the *AEO99* reference case assumptions in the electricity market module of *CEF*-NEMS. First, co-firing of biomass in coal plants was incorporated, which is a feature later added to NEMS by EIA. Second, modifications were made in *CEF*-NEMS to certain costs applied to wind generation. *AEO99* assumed decreasing capital costs for wind generation technology due to learning effects as more units are built but higher resource costs once low-cost wind resources were used, to reflect decreasing quality of available resources, transmission network upgrades, and alternative uses for land. In *CEF*-NEMS, these costs were reduced and regional limits on the growth in wind generation in a single year were removed, omitting some important costs necessary in evaluating wind supply. Although these modifications had little impact on the *CEF* business-as-usual case, they had a much larger impact on the moderate and advanced cases.

Third, *CEF*-NEMS removed a constraint on the expansion of geothermal generation. In *AEO99*, it was assumed that a new geothermal site was limited to 50 megawatts of capacity, with a 3-year delay before additional capacity could be built at that site, reflecting the geothermal industry practice of gradual site testing and phased commercial expansion. Although a 50-megawatt constraint may have been too restrictive for some sites, particularly in cases with a high demand for renewable technologies, removing the constraint altogether could result in unrealistic projections of geothermal builds.

Finally, the revision to the electricity generation assumptions that had the most impact on the results of the *CEF* business-as-usual case was to reduce the cost of nuclear plant refurbishment and relicensing. In *AEO99*, it was assumed that a charge of $150 per kilowatt would be required to operate a nuclear unit beyond 30 years of age for an additional 10 years. An additional charge of $250 per kilowatt would be required to operate a unit for 20 years past its current license expiration date of 40 years. These costs were designed to capture age-induced impacts on operating costs of the unit. At both steps of this cost evaluation, if the total costs of continuing to operate the unit were less than the costs of building new capacity, the unit would continue in operation. In *CEF*-NEMS, the 40-year charge was reduced to $50 per kilowatt. As a result, fewer nuclear plants were retired in the *CEF* business-as-usual case than in the *AEO99* reference case, reducing the need for additional capacity additions, which are largely fossil fuel fired, and making CO_2 emissions reductions easier in the *CEF* moderate and advanced cases.

In the *AEO99* reference case, nuclear capacity declined from 99 gigawatts in 1997 to 49 gigawatts in 2020; in the *CEF* business-as-usual case, nuclear capacity declined to 72 gigawatts. As a result, nuclear generation, which declined from 629 to 359 billion kilowatthours between 1997 and 2020 in *AEO99*, only declined to 520 billion kilowatthours in 2020 in the *CEF* business-as-usual case. Due to more nuclear and less fossil-fired generation,

[12] Interlaboratory Working Group, *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*, ORNL/CON-444 and LBNL-40533 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, September 1997), web site www.ornl.gov/ORNL/Energy_Eff/labweb.htm.

electricity generator CO_2 emissions in the *CEF* business-as-usual case reached 709 million metric tons carbon equivalent, as compared with 746 million metric tons carbon equivalent in *AEO99*.

Since *AEO99*, the methodology for projecting nuclear retirements has been revised and aging-related cost assumptions have been lowered. In *AEO2001*, more gradual increases in annual expenditures due to aging are assumed, rather than a one-time investment, and mainly after 40 years of operation. From 30 to 40 years of age, the aging-related cost is assumed to increase by $0.25 per kilowatt per year; from age 40 to 50 an additional annual cost of $13.50 per kilowatt is assumed; and from age 50 to 60 an additional annual cost of $25 per kilowatt is assumed. In *AEO2001*, nuclear capacity is projected to be 72 gigawatts in 2020, the same as in *CEF*. In 2020, nuclear generation is projected to be 574 billion kilowatthours in *AEO2001*, with electricity generator CO_2 emissions of 772 million metric tons carbon equivalent. The higher projection for emissions is largely due to higher projected economic growth and electricity demand in *AEO2001*.

Total primary energy consumption in the *AEO99* reference case and the *CEF* business-as-usual case was projected to increase from 94 to 120 quadrillion Btu between 1997 and 2020. Primarily as a result of more nuclear generation, total projected CO_2 emissions in the *CEF* business-as-usual case reached 1,922 million metric tons carbon equivalent in 2020, as compared with 1,975 million metric tons carbon equivalent in the *AEO99* reference case. In *AEO2001*, total energy consumption in 2020 is projected to be 127 quadrillion Btu, with CO_2 emissions of 2,041 million metric tons carbon equivalent.

Summary of Results in *CEF*

Many of the policies in *CEF*, which are enumerated in Chapter 3, were aimed at encouraging the adoption and penetration of more energy-efficient technologies. These included financial incentives, research and development, efficiency standards (which are important policies in the buildings sectors), and voluntary agreements and deployment programs. As requested, this analysis incorporates the same policies assumed by the *CEF* analysts where possible; however, several general issues are noted below that may call these assumptions into question:

- Many of the *CEF* policies are based on additional funding for technology research and development, totaling $1.4 billion (1997 dollars) per year in the moderate case and $2.8 billion per year in the advanced case, with the costs shared between the public and private sectors. These included most of the *CEF* transportation policies, the *CEF* policies for electricity generation technologies, and, to a lesser extent, the policies for technologies in the other end-use sectors. The impacts of research and development funding for new technologies, whether ongoing or incremental, are difficult to quantify. Some of the proposed funding for technology may achieve benefits only in a long time frame (beyond 2020) or may not achieve success at all, and predicting which technology development will be successful is highly speculative. A specific link cannot be established between levels of funding for research and development and specific improvements in the characteristics and availability of energy technologies. Because these funding increases are questionable and the link between funding and technology development is tenuous, the suggested technology improvements based on these research and development policies are also questionable. Although the environmental benefits of the advanced case would be higher than those of the moderate case, the associated costs would also be higher. The environmental benefits are not quantified.[13]

- Many *CEF* policies, particularly in the industrial sector, relied on voluntary and information programs. Similar to assessing the impact of increased research and development funding, it is also difficult to analyze the impacts of information programs, voluntary initiatives, and partnerships on realized technology development and deployment. Some voluntary programs appear to have achieved success. Although the benefits of past efforts are difficult to quantify, they are generally assumed in the efficiency trends in the reference case.

- Some of the *CEF* policies required legislative or regulatory actions that may not be enacted. These included tax credits for certain high-efficiency vehicles and renewable generation technologies, new equipment standards, national electricity industry restructuring, a renewable portfolio standard (which requires a specified percentage of electricity sales to be generated from renewable sources other than hydropower), new particulate standards, and pay-at-the-pump motor vehicle insurance. To the extent that these are not enacted or are enacted at later dates than assumed in *CEF*, the results of the *CEF* analysis would be altered.

[13]*CEF* estimated the research and development funding, plus program implementation, administrative, and incremental technology investment costs. Comparing those costs with reductions in energy expenditures, *CEF* concluded there would be a net saving. The present analysis does not estimate the costs of the *CEF* policies.

- Certain technology cost reductions in the *CEF* analysis appear unrealistic. For example, in the residential sector, the cost of the most efficient unit for some appliances was reduced to the cost of the least efficient unit. It seems unlikely that either research and development or voluntary programs could reduce technology costs to that level. Other technology assumptions also appear unrealistic—for example, the assumption that generating plants using CO_2 sequestration technology would achieve the same efficiency as those that do not.

- In the residential and commercial sectors, consumer hurdle rates were significantly reduced. These hurdle rates represent the willingness of consumers to invest in energy-efficient equipment. In practice, hurdle rates are often much higher than the cost of borrowing money, for reasons including transaction costs, a desire for equipment features other than efficiency, and builders or building owners who purchase the equipment but do not pay the energy bills. Although these hurdle rate reductions in the *CEF* analysis were attributed to voluntary programs and other policies, they appear to be optimistic in their valuation of consumer desire for energy efficiency, resulting in hurdle rates of 15 percent, which are less than the interest rates charged by many credit cards.

- In the *CEF* analysis, the growth rates for miscellaneous electricity uses in both the residential and commercial sectors were significantly reduced. Miscellaneous electricity uses consist of a variety of smaller end uses not individually identified in NEMS. Energy used by small heating elements, motors, and electronic devices comprises miscellaneous uses in the residential sector. In the commercial sector, miscellaneous electricity uses include a myriad of devices such as transformers, automated teller machines, traffic lights, telecommunications equipment, and medical equipment.[14] The modifications to miscellaneous electricity growth rates were largely attributed by the *CEF* authors to voluntary programs, State market transformation programs, and, in the advanced case, to a 2004 commercial transformer standard. The reductions in the growth rates appear unrealistic given the equipment in these categories, where it is unlikely that the use of the equipment will be greatly reduced. Although there is the potential for some efficiency improvements, it is unlikely that efficiencies could improve enough to reach the consumption levels achieved in *CEF*. Some of these small appliances include heating elements that cannot readily incorporate increased efficiency.

- From a macroeconomic perspective, the crucial assumption underlying the *CEF* study was that the economy currently is not using its resource base efficiently—i.e., that the economy is not on the production possibilities curve. The study assumed that overcoming large-scale market failures can place the economy on this frontier with less energy use and fewer emissions. However, many of the presumed market failures are actually rational, efficient decisions on the part of consumers given current technology, expected prices for energy and other goods and services, and the value they place on their time to evaluate options. As Henry Jacoby points out, "The key difference between market barriers and market failures is that correcting failures may sometimes produce a net benefit, whereas overcoming barriers always involves cost."[15]

As noted in Table 3, *CEF* projected lower energy consumption and CO_2 emissions in the business-as-usual case than in the *AEO2001* reference case, due to modifications to the *AEO99* reference case in the *CEF* analysis and to the changes in the model methodologies and assumptions, particularly the economic growth rates, in *AEO2001* relative to *AEO99*. *CEF* projected that the policies in the moderate case and the advanced case could further reduce total energy consumption by 8 percent and 19 percent, respectively, in 2020 relative to the business-as-usual case. In the advanced case, *CEF* projected that total energy consumption would increase at an average annual rate of 0.4 percent between 1997 and 2010 then decrease at an average annual rate of 0.3 percent between 2010 through 2020. Given growing population and a growing economy, an actual decrease in energy consumption as projected in *CEF* would appear unlikely without significant increases in energy prices. Total energy consumption in the *CEF* advanced case was projected to reach 99 quadrillion Btu in 2010, declining to 97 quadrillion Btu in 2020.

In 2020, the use of renewable energy was projected in the *CEF* analysis to be 11 percent higher and 27 percent higher in the moderate and advanced cases, respectively, than in the business-as-usual case. In the advanced case, renewable generation was encouraged by policies such as a renewable portfolio standard, a carbon fee of $50 per metric ton carbon equivalent, and a proposed extension of the production tax credit, which was applied only to wind and biomass in the moderate case, to all nonhydropower renewables. In both cases,

[14] Major uses of electricity include space heating, space cooling, water heating, refrigeration, cooking, and lighting in the residential sector. All of these uses plus ventilation and office equipment are specifically identified as end uses in the commercial sector. Miscellaneous uses include all other end uses.

[15] H. Jacoby, "The Uses and Misuses of Technology Development as a Component of Climate Change Policy," presentation to the America Council for Capital Formation, Center for Policy Research (October 1998).

CEF projected lower fossil fuel consumption and fewer nuclear power retirements. In *CEF*, natural gas consumption was projected to be lower in both cases than in the business-as-usual case and did not increase in the advanced case compared to the moderate case despite a sharp reduction in coal use, due to the greater use of renewables and nuclear power and projected efficiency improvements that reduce overall energy consumption.

In percentage terms, the projected reductions in CO_2 emissions that occurred in the *CEF* cases were greater than the reductions in energy consumption due to the shifts to less carbon-intensive fuels. In the moderate case, projected CO_2 emissions were 5 percent and 9 percent lower in 2010 and 2020, respectively, than in the business-as-usual case. However, emissions remained significantly higher than recent historical levels. Projected CO_2 emissions were reduced by 17 percent and 30 percent in 2010 and 2020, respectively, in the advanced case, compared to the business-as-usual case. In 2010, CO_2 emissions were projected to reach 1,463 million metric tons carbon equivalent in the advanced case, which is less than the 1997 level (estimated at 1,480 million metric tons carbon equivalent in *CEF* and now estimated at 1,493 million metric tons carbon equivalent in the *U.S. Carbon Dioxide Emissions from Energy Sources: 2000 Flash Estimate*[16]). By 2020 in the advanced case, *CEF* projected that CO_2 emissions would decline further to 1,347 million metric tons carbon equivalent, essentially the same as the level of 1,349 million metric tons carbon equivalent estimated for 1990.

Particularly in the advanced case, the largest reductions in CO_2 emissions, in percentage terms, occurred in the residential and commercial sectors due to increased energy efficiency and the use of less carbon-intensive fuels to generate the electricity used in those sectors. As noted above, however, the application of lower hurdle rates in the *CEF* analysis implicitly assumed changes in consumer buying practices that are unsupported by history. The transportation sector had the smallest percentage reductions in CO_2 emissions. Although efficiencies were assumed to improve for all modes of transportation, the transportation sector has limited ability to shift from its almost exclusive reliance on petroleum to other, less carbon-intensive fuels. Comparing the advanced case to the moderate case, the additional reductions in CO_2 emissions were largely due to policies in the advanced case that promoted less electricity generation from coal and more from natural gas, renewables, and nuclear power, including the CO_2 trading program, which increased prices for fossil fuels and for electricity delivered to customers.

Representing the *CEF* Policies in NEMS

The request for this analysis to EIA specified that two cases be analyzed "assuming the moderate [advanced] supply and demand-side policy case of the Clean Energy Futures study." As noted earlier, however, *CEF* was based on the *AEO99* version of NEMS, and there

Table 3. Energy Consumption and CO_2 Emissions in *AEO2001* and the *CEF* Cases, 2010 and 2020

Year	Projection	Primary Energy Consumption: Quadrillion Btu	Primary Energy Consumption: Percent Change From *CEF* Business-As-Usual	CO_2 Emissions[a]: Million Metric Tons Carbon Equivalent	CO_2 Emissions[a]: Percent Change From *CEF* Business-As-Usual
1997	—	94.3	—	1,493	—
2000	—	98.5	—	1,558	—
2010	*AEO2001*[b]	114.1	—	1,809	—
	CEF Business-As-Usual	110.4	—	1,769	—
	CEF Moderate	106.5	-4	1,684	-5
	CEF Advanced	99.3	-10	1,463	-17
2020	*AEO2001*[b]	127.0	—	2,041	—
	CEF Business-As-Usual	119.8	—	1,922	—
	CEF Moderate	110.1	-8	1,740	-9
	CEF Advanced	96.8	-19	1,347	-30

[a]CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
[b]As noted in the letter of request in Appendix A, the *AEO2001* reference case is the starting point for this analysis.
Note: *AEO2001 = Annual Energy Outlook 2001*; Btu = British thermal unit; *CEF = Clean Energy Future*; CO_2 = carbon dioxide.
Sources: Energy Information Administration (EIA), *Annual Energy Review 2000*, DOE/EIA-0384(2000) (Washington, DC, August 2001); EIA, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001)(Washington, DC, December 2000); EIA, *U.S. Carbon Dioxide Emissions from Energy Sources: 2000 Flash Estimate* (Washington, DC, June 2001), web site www.eia.doe.gov/oiaf/1605/flash/sld001.htm; Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), p. ES.5.

[16]Energy Information Administration, *U.S. Carbon Dioxide Emissions from Energy Sources: 2000 Flash Estimate* (Washington, DC, June 2001), web site www.eia.doe.gov/oiaf/1605/flash/sld001.htm.

have been significant changes to the model and to the assumptions for *AEO2000* and particularly *AEO2001*. Consequently, directly using the energy demands or the energy demand changes that occurred in *CEF* is not appropriate for this analysis.

One of the most significant changes between *AEO99* and *AEO2001* is the assumed rate of economic growth. In *AEO99*, the U.S. economy was projected to grow at an average annual rate of 2.0 percent between 1999 and 2020; however, the growth rate in *AEO2001* is projected to be 3.0 percent. Part of the upward revision to the growth rate that occurred in *AEO2001* is due to statistical and definitional changes in the National Income and Product Accounts; however, the projection also reflects a more optimistic view of long-run economic growth. The more rapid projected growth in GDP affects the projected growth in other key economic drivers—for example: commercial floorspace growth, 1.3 percent per year in *AEO2001* vs. 0.8 percent per year in *AEO99*; industrial gross output growth, 2.6 percent per year vs. 1.9 percent per year; and real disposable personal income growth, 3.0 percent per year vs. 2.3 percent per year.

In general, more rapid projected economic growth leads to increased demand for energy services and more energy consumption. In addition, the growth rate for electricity demand is reevaluated in *AEO2001*, particularly for computers, office and other electrical equipment and appliances, and miscellaneous energy uses, in accordance with recent trends. Electricity demand is projected to increase at an average annual rate of 1.8 percent between 1999 and 2020 in *AEO2001*, compared with an average of 1.4 percent projected in *AEO99*. In part due to higher economic growth but also as the result of a reestimation of projected light-duty vehicle travel, travel in *AEO2001* increases at an average annual rate of 1.9 percent from 1999 through 2020, as compared with 1.7 percent in *AEO99*. Overall, total energy consumption in *AEO2001* is projected to increase at an average annual rate of 1.3 percent from 1999 to 2020, as compared with an average annual rate of 1.0 percent in *AEO99*.

Partly offsetting the higher projected economic growth in *AEO2001* is more rapid improvement in energy intensity. In the commercial sector, the effects of Executive Order 13123, signed by President Clinton in June 1999, mandating reduced energy use in Federal facilities, and a new fluorescent ballast standard promulgated in September 2000 mitigate some of the previously expected growth in energy consumption. Improvements in industrial energy intensity are reevaluated in *AEO2001*. As a result, primary energy consumption per dollar of output in the industrial sector is projected to decrease at an average annual rate of 1.5 percent in *AEO2001*, compared with 1.1 percent in *AEO99*. Primary energy intensity of the U.S. economy is projected to decline at an average annual rate of 1.6 percent in *AEO2001*, compared with 1.0 percent in *AEO99*. On the other hand, starting with *AEO2001*, the size of new houses is projected to increase over time, in accordance with recent trends, which tends to increase the energy intensity of households. In 2020, the average home is 2 percent larger in the *AEO2001* projections than in *AEO99*.

Energy price projections have also been revised between *AEO99* and *AEO2001*. The most significant change is for natural gas prices. Converting the energy prices in *AEO99* to 1999 dollars as reported in *AEO2001*, projected natural gas wellhead prices in 2020 are higher by 13 percent in *AEO2001* and 12 percent in this study, in part due to higher projected demand for natural gas in *AEO2001*. Partly due to higher projected natural gas prices, the average delivered electricity price in 2020 is projected to be 3 percent higher in *AEO2001* than in *AEO99*. These price changes affect the economics of technology adoption and penetration. Projected world oil prices and minemouth coal prices in 2020 in *AEO2001* are similar to those in *AEO99*.

Other assumption changes also affect technology adoption. As an example, in the transportation demand module of NEMS, the assumed incremental cost of a hybrid electric vehicle relative to a conventional vehicle has been reduced from $13,600 in *AEO99* to $8,500 in *AEO2001*. The introduction date has also been advanced from 2003 to 2000, reflecting the commercialization of these vehicles.

Overall, these revisions to the reference case projections indicate that the demand impacts of improved technology assumptions, as reflected in *CEF* and based on *AEO99*, could not simply be applied to the *AEO2001* projections for the purposes of this analysis.

In some cases, the *CEF* policies overlap with or have been overtaken by changes that have occurred over time or within NEMS. For example, some policies were expected in the *CEF* analysis to be instituted in 2000 or 2001, which is no longer plausible. Also, residential equipment standards proposed in *CEF* are modified in this analysis to account for the standards announced in January 2001, as later modified by the Bush Administration. The January 2001 standards included a 13 SEER (seasonal energy efficiency ratio, calculated as Btu of output per watthour of input) for central air conditioners and heat pumps, which was revised by the current administration to 12 SEER, as assumed in this analysis. The revision is being challenged in court, and a final rulemaking is expected in early 2002.

Modeling enhancements have also been made to NEMS since the *AEO99* version, and several have a significant impact on the results. A few of the more significant examples are noted below:

- The representation of industrial and commercial cogeneration has been enhanced to include an explicit evaluation of the costs and performance of various cogeneration technologies.[17] In addition, a representation of distributed generation has been added to the electricity generation, residential, and commercial modules. Both economically based and program-driven installations are represented, as well as the projected effects on purchased electricity in the residential and commercial sectors and, for cogeneration, on fuel to meet space heating and water heating demand.

- In the residential module, the building shell methodology, which had been based in *AEO99* on an assumption of the improvement in new buildings over time, has been replaced by an explicit evaluation of the costs of various shell efficiency levels integrated with the choice of heating and air-conditioning equipment. As a result, policies aimed at improving residential shell efficiency cannot be addressed in the same fashion as in the *AEO99* version of NEMS.

- In the transportation module, light-duty vehicles are now represented by 20 rather than 10 vintages. The methodology for vehicle choice in *AEO2001* competes alternative-fueled and advanced technology vehicles directly with conventional vehicles. In *AEO99*, a generic alternative technology competed with conventional vehicles. Also, hybrid electric vehicles are no longer considered to be an advanced technology but, rather, another conventional technology.

- *AEO2001* includes a redesigned component for geothermal electricity generation with a methodology more similar to those of the other renewable technologies, providing a comparable evaluation of the potential penetration of geothermal energy relative to the other technologies.

- Two modifications have been made in the electricity generation sector of NEMS since *AEO99* that tend to reduce the economic retirements of existing power plants. First, expectations of electricity demand growth, which are used internally to determine the requirements for new generation capacity, tended to be too high. This resulted in higher reserve margins and capacity additions. The methodology has been revised so that the initial electricity demand expectations used for capacity expansion are more in line with resulting forecasted demands. Also, projected capital costs for new capacity in *AEO2001* are generally higher for fossil-fired units than in *AEO99*, particularly for natural-gas-fired plants, which are 30 to 50 percent more costly, reducing retirements because the cost of replacing existing plants has increased.

In order to represent the *CEF* programs within NEMS for this study, each policy and its implementation in *CEF* were examined. Where possible, policies are explicitly represented, such as tax credits and efficiency standards. Many policies in *CEF*, including research and development and voluntary programs, were analyzed separately by the *CEF* analysts, and the results were introduced into *CEF*-NEMS through changes in parameters and assumptions, such as technology costs and performance and hurdle rates. For this study, EIA analysts generally implemented the same changes, on a percentage basis, into the current version of NEMS. Where *CEF* policies are date-dependent, due to the passage of time, as noted above, they are adjusted for the year of implementation, which has an impact on the level of penetration. The specific implementation of the *CEF* policies is discussed in Chapter 3.

As requested by Senators Jeffords and Lieberman, the overall goal of the EIA implementation of *CEF* policies is to emulate the analysis originally performed by the *CEF* analysts, while adjusting for the model enhancements and updated assumptions in *AEO2001*. In addition, the analysis is adjusted for any changes in energy programs and policies that have occurred since the *CEF* analysis. Therefore, although actual demand projections and demand reductions in the EIA analysis due to *CEF* policies may not match those in the published *CEF* analysis, the EIA analysis captures the essence of an updated *CEF* analysis.

[17] In *CEF*, policies for encouraging industrial cogeneration, or combined heat and power, were analyzed outside of *CEF*-NEMS and were not included in the integrated analysis or results.

2. Analysis of Strategies with *AEO2001* Technology Assumptions

In the request from Senators Jeffords and Lieberman, the Energy Information Administration (EIA) was asked to analyze the impacts of emissions limits on nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon dioxide (CO_2), and mercury (Hg) from electricity generators against four cases with different assumptions concerning technology development and policies to reduce energy consumption and promote the use of cleaner technologies. The first case uses the reference case technology characteristics in the *Annual Energy Outlook 2001* (*AEO2001*).[18] The second case assumes the high technology assumptions for energy demand, electricity generation, and fossil fuel supply in *AEO2001*. The other two cases are based on the moderate and advanced cases from *Scenarios for a Clean Energy Future* and are discussed in Chapter 3.[19] In all four cases, the same emissions limits are imposed on all electricity generators, excluding cogenerators.[20] The start date for the reductions is 2002. By 2007, NO_x emissions are reduced to 75 percent below 1997 levels, SO_2 emissions to 75 percent below the full implementation of the Phase II requirements under Title IV of the Clean Air Act Amendments of 1990, Hg emissions to 90 percent below 1999 levels, and CO_2 emissions to 1990 levels.

Although the analysis in *AEO2001* focuses on the reference case, a number of sensitivity cases are presented in the report to explore various uncertainties in energy markets, including world oil prices, U.S. economic growth, technology development and adoption, nuclear costs and construction times, and oil and natural gas resources. Many of these sensitivities are analyzed by changing the reference case assumptions in one energy sector at a time. One case in *AEO2001* combines slower technology improvements relative to the reference case for the residential, commercial, industrial, and transportation demand sectors and for advanced fossil generating technologies. Another case in *AEO2001* combines more rapid technology improvements for the same sectors and for new renewable generating technologies.

The advanced technology case in this analysis combines the high technology case in *AEO2001* with lower aging-related costs for nuclear power plants and the high technology assumptions for fossil fuel supply, including lower costs and higher finding rates (reserve additions per well) and success rates (successful wells drilled) for oil and gas supply, and higher productivity and lower costs for coal production, relative to the reference case. This analysis does not address either the likelihood that all the assumptions in this case would occur or the costs that would be required to achieve these technology improvements. However, under current levels of research and development, the reference case is considered to be the most likely case for technology development. This chapter presents the impact of the advanced technology assumptions relative to the reference case and the analysis of the emissions limits for both the reference and the advanced technology cases.

Impact of Emissions Limits on the Reference Case

With the imposition of emissions limits on the reference case, the average delivered price of electricity in 2020 is projected to be 33 percent higher than in the reference case due to the cost to electricity generators of meeting the limits. Projected wellhead natural gas prices are also higher by 20 percent as a result of higher natural gas consumption by electricity generators. Due to the higher energy prices that result from the assumed emissions limits, total energy consumption is projected to be reduced by 7 quadrillion British thermal units (Btu) in 2020, or 5 percent (Figure 2), and projected energy expenditures are higher. The primary energy intensity of the economy—defined as total energy consumption per dollar of gross domestic product (GDP)—is projected to decline at an average annual rate of 1.9 percent between 1999 and 2020, compared to 1.6 percent in the reference case (Figure 3).

Projected consumption of coal and electricity is lower with the emissions limits than in the reference case without the limits; however, as electricity generators reduce the use of coal, the projected use of existing

[18]Energy Information Administration, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001) (Washington, DC, December 2000), web site www.eia.doe.gov/oiaf/aeo/index.html.

[19]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), web site www.ornl.gov/ORNL/Energy_Eff/CEFOnep.pdf.

[20]At this time, emissions limits on cogenerators are not represented.

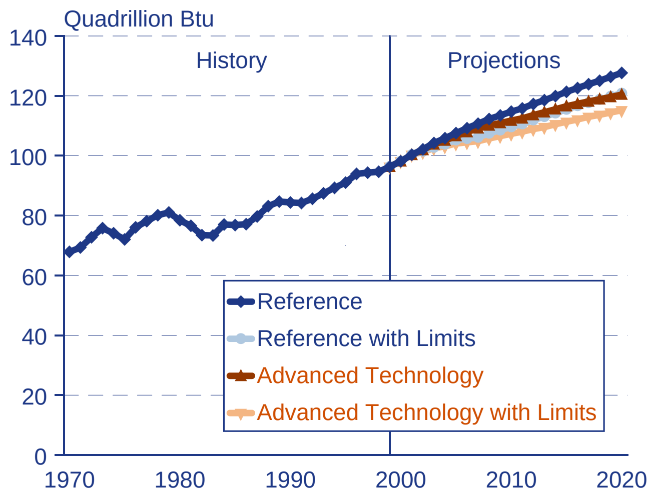
nuclear power plants and natural gas and renewable generating technologies is higher, raising the consumption of these energy sources, relative to the reference case. Because of reduced energy consumption and the shift in the fuel mix to more natural gas, renewables, and nuclear power, projected CO_2 emissions in 2020 are reduced by 287 million metric tons carbon equivalent, or 14 percent, relative to the reference case, and other emissions are also reduced (Figures 4 through 7).

Electricity and Renewables

The introduction of emissions limits in the reference case results in substantially higher projected average delivered electricity prices relative to the reference case. Projected prices are 31 percent higher in 2010 and 33 percent higher in 2020 even as consumers reduce their consumption of electricity by 6 and 9 percent in 2010 and 2020, respectively (Figure 8 and Table 4). Annual expenditures are expected to be $158 more per household in 2010 and $154 more in 2020 as revenue to electricity providers is $58 billion and $59 billion higher in 2010 and 2020, respectively.

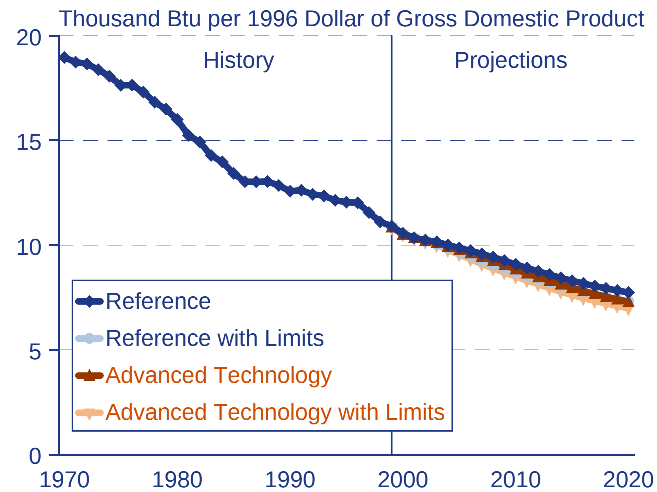
Prices are expected to increase because the cost of producing power with emission limits is more expensive than without limits. There are additional costs associated with the installation of emission control equipment, the purchase of emissions permits, and costs for fuels

Figure 2. Energy Consumption in Four Cases, 1970-2020



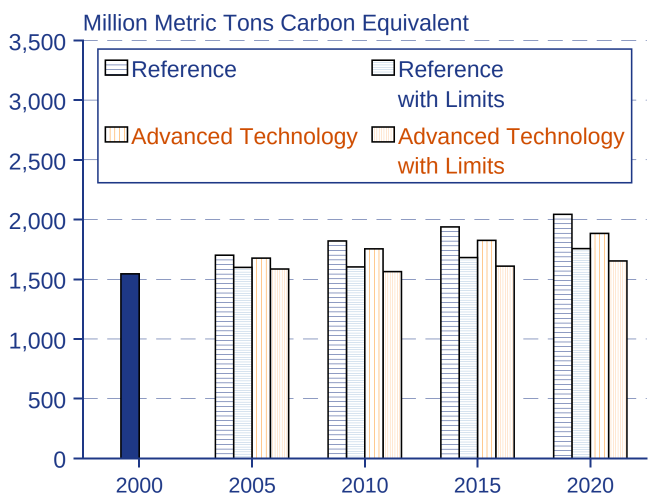
Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 3. Primary Energy Intensity in Four Cases, 1970-2020



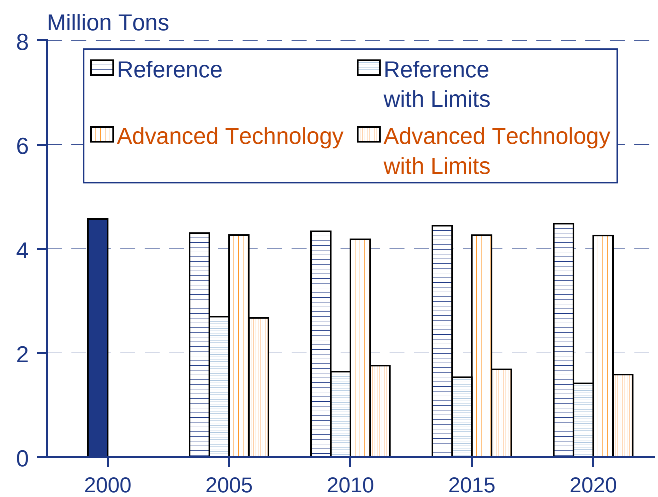
Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 4. Carbon Dioxide Emissions in Four Cases, 2000-2020



Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 5. Nitrogen Oxides Emissions from Generating Units (Excluding Cogenerators) in Four Cases, 2000-2020

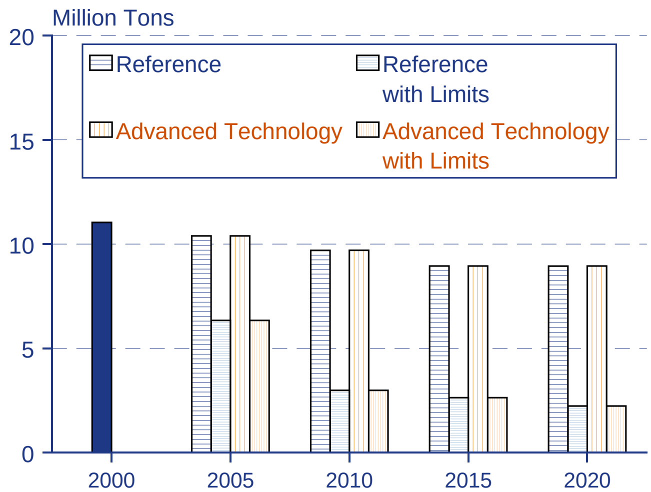


Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

used to generate electricity. For example, in the case with emissions limits, 37 gigawatts of flue gas desulfurization equipment are expected to be constructed in 2020 compared with 17 gigawatts in the reference case. There are also additional investments for fabric filters and spray coolers to reduce emissions of Hg. Prices for fossil fuels are also expected to be higher. Natural gas prices to electricity generators are projected to be $4.52 per thousand cubic feet in 2020 in the reference case with limits compared with $3.68 in the reference case without limits. The effective price of natural gas to electricity generators, which includes the cost of a CO_2 allowance, reaches $6.31 per thousand cubic feet when the emissions limits are imposed. The higher projected price for natural gas also results from the higher costs associated with producing additional quantities of natural gas in the case with limits, which raises the average wellhead price of natural gas. Although the price of coal delivered to electricity generators is lower in 2020 when emissions limits are imposed, $17.28 per short ton compared to $19.34 per short ton in the case without limits, the effective price is projected to reach $81.28 per short ton, after including the CO_2 allowance cost.

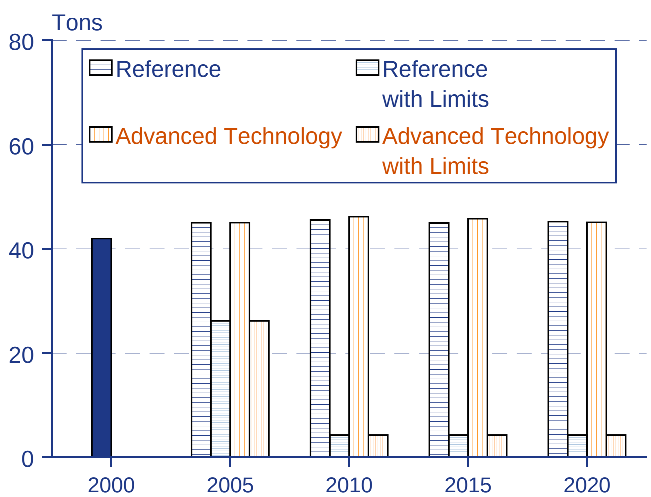
The projected higher electricity prices cause consumers to reduce their use of electricity, although higher projected natural gas prices dampen the impact of the higher electricity prices. Sales of electricity are expected to be lower by 261 billion kilowatthours in 2010 and by 443 billion kilowatthours in 2020 (Figure 9). These lower levels of consumption, combined with fuel switching by electricity generators, are reflected in the levels and types of generation. Projected coal-fired generation is reduced by 962 billion kilowatthours in 2010 and by 1,261 billion kilowatthours in 2020, 43 percent and 55 percent, respectively (Figure 10). The lower levels of coal-fired generation are expected to occur because emissions limits on controlled gases and Hg discourage the use of coal more than other fuels. Compared with coal, natural gas has lower emissions per unit, resulting in higher projected consumption levels for natural gas compared with the reference case without limits. The use of renewable sources and nuclear power is also expected to be higher in the case with limits because the costs of coal- and petroleum-fired generation are relatively more expensive. By 2010, nonhydropower renewable technologies, including geothermal, wind, biomass, municipal solid waste and landfill gas, and solar, are expected to produce 94 billion kilowatthours more than

Figure 6. Sulfur Dioxide Emissions from Generating Units (Excluding Cogenerators) in Four Cases, 2000-2020



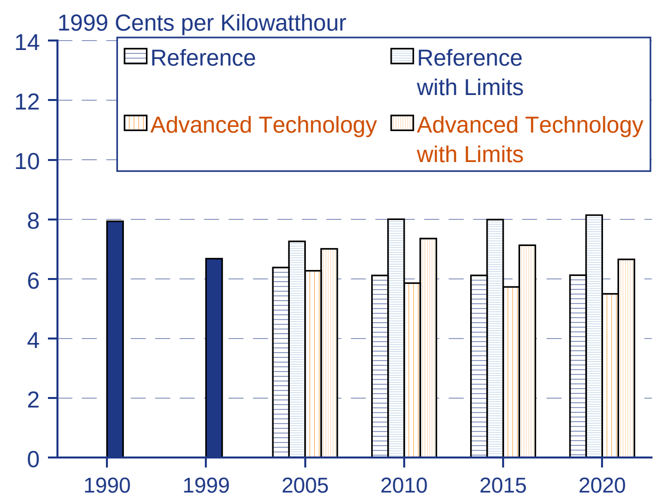
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 7. Mercury Emissions from Generating Units (Excluding Cogenerators) in Four Cases, 2000-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 8. Electricity Prices in Four Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Table 4. Electricity Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
		2010			
Average Delivered Electricity Prices (1999 Cents per Kilowatthour)	**6.7**	**6.1**	**8.0**	**5.9**	**7.4**
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,133**	**3,872**	**4,049**	**3,835**
Generation, Excluding Cogenerators (Billion Kilowatthours)	**3,369**	**4,204**	**3,914**	**4,125**	**3,885**
Coal	1,830	2,238	1,276	2,240	1,324
Natural Gas	370	826	1,395	719	1,292
Nuclear Power	730	720	741	744	744
Renewables, Excluding Hydropower	46	95	189	101	213
Hydropower	310	301	303	301	302
Emissions, Excluding Cogenerators					
SO_2 (Million Tons)	13.5	9.7	3.0	9.7	3.0
NO_x (Million Tons)	5.4	4.3	1.6	4.2	1.8
Hg (Tons)	43.4	45.5	4.3	46.2	4.3
CO_2 (Million Metric Tons Carbon Equivalent)	556	691	476	667	475
Allowance Prices					
SO_2 (1999 Dollars per Ton)	0	180	46	168	152
NO_x (1999 Dollars per Ton)[a]	0	0	0	0	0
Hg (Million 1999 Dollars per Ton)	0	0	482	0	510
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	93	0	69
Annual Household Electricity Bill (1999 Dollars)	**892**	**936**	**1,094**	**901**	**1,013**
Total Electricity Revenue (Billion 1999 Dollars)	**222**	**252**	**310**	**239**	**284**
		2020			
Average Delivered Electricity Prices (1999 Cents per Kilowatthour)	**6.7**	**6.1**	**8.1**	**5.5**	**6.7**
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,763**	**4,320**	**4,610**	**4,294**
Generation, Excluding Cogenerators (Billion Kilowatthours)	**3,369**	**4,821**	**4,311**	**4,674**	**4,309**
Coal	1,830	2,302	1,041	2,246	1,146
Natural Gas	370	1,488	2,072	1,331	1,911
Nuclear Power	730	610	669	672	720
Renewables, Excluding Hydropower	46	99	217	109	223
Hydropower	301	300	302	300	301
Emissions, Excluding Cogenerators					
SO_2 (Million Tons)	13.5	9.0	2.2	9.0	2.2
NO_x (Million Tons)	5.4	4.5	1.4	4.3	1.6
Hg (Tons)	43.4	45.2	4.3	45.1	4.3
CO_2 (Million Metric Tons Carbon Equivalent)	556	773	475	716	474
Allowance Prices					
SO_2 (1999 Dollars per Ton)	0	200	221	145	703
NO_x (1999 Dollars per Ton)[a]	0	0	0	0	0
Hg (Million 1999 Dollars per Ton)	0	0	306	0	374
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	122	0	58
Annual Household Electricity Bill (1999 Dollars)	**892**	**980**	**1,134**	**886**	**974**
Total Electricity Revenue (Billion 1999 Dollars)	**222**	**291**	**350**	**254**	**288**
Cumulative Additions of Emissions Control Equipment, 1999-2020 (Gigawatts)					
SO_2 Scrubbers	—	17.5	37.0	9.8	40.5
Selective Catalytic Reduction (SCRs)	—	91.1	101.9	91.0	98.2
Selective Noncatalytic Reduction (SNCRs)	—	46.0	37.1	27.2	39.1
Hg Fabric Filters	—	0.0	88.3	0.0	95.7
Hg Spray Coolers	—	0.0	49.2	0.0	63.5
Cumulative Resource Cost, 2001-2020 (Billion 1999 Dollars)	**—**	**2,031**	**2,208**	**1,837**	**1,979**

[a]Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.

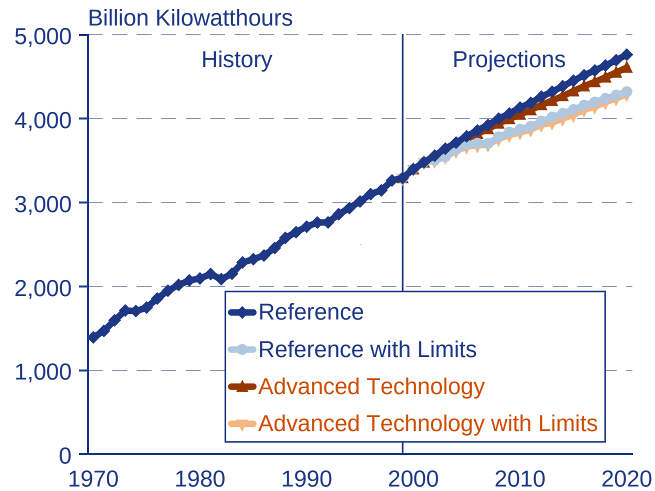
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

the 95 billion kilowatthours generated in the reference case without limits. In 2020, these renewable technologies are expected to generate 217 billion kilowatthours in the reference case with emissions limits, compared to 99 billion kilowatthours in the case without limits. Projected nuclear generation is higher by 21 billion kilowatthours in 2010 and by 59 billion kilowatthours in 2020, 3 percent and 10 percent, respectively, compared to the case without limits.

The higher projected price for electricity is due, in part, to the costs of obtaining emission permits. CO_2 emissions permit costs are included in the price of the fossil fuel to electricity generators. For the other three emissions, the permit costs are effectively included in the electricity price based on the cost incurred by the marginal generator.

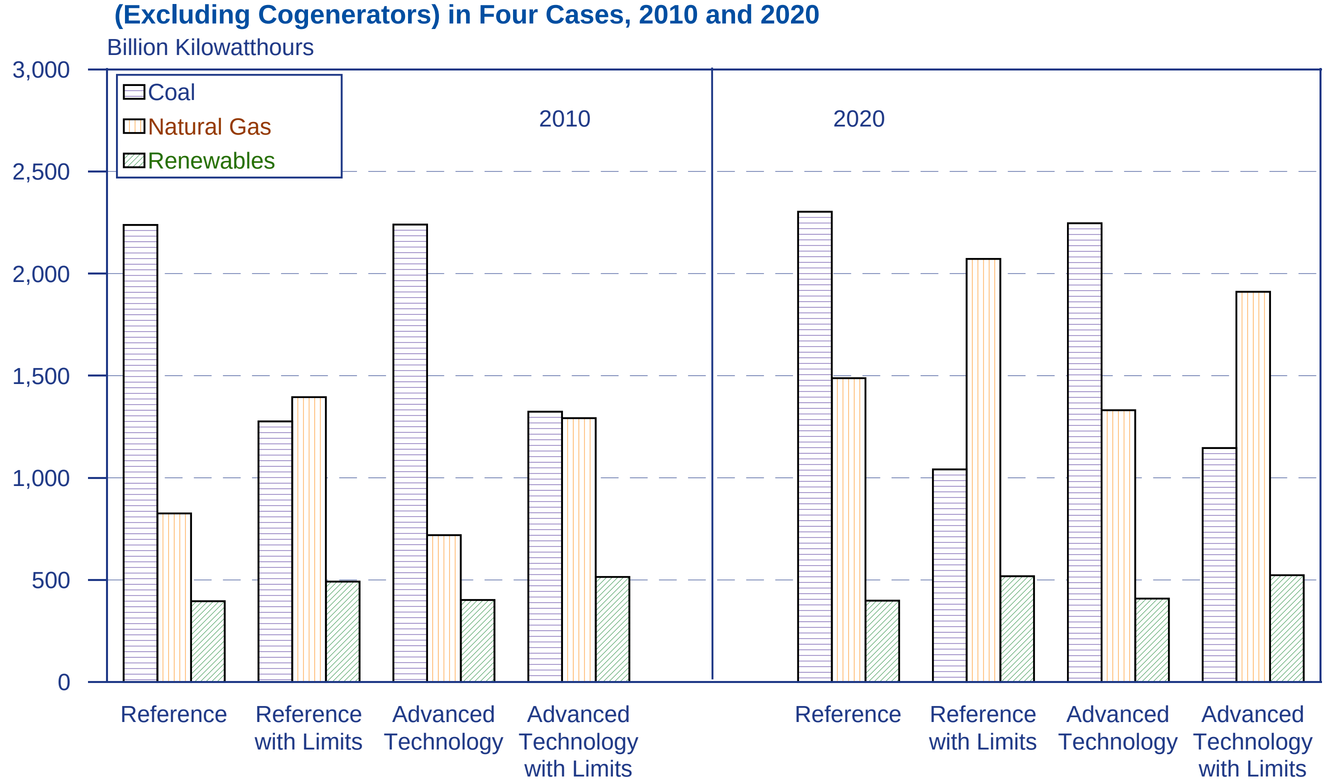
The costs for SO_2 permits are projected to be $46 per ton in 2010 and $221 per ton in 2020 in the reference case with emissions limits (Figure 11). The current price level for SO_2 permits is approximately $175 per ton.[21] In 2020, the cost of SO_2 permits is projected to be $21 per ton higher than in the reference case without emissions limits, reflecting lower emissions limits and required investments in emissions control equipment. The price for CO_2 permits is expected to be $93 per metric ton carbon equivalent in 2010, increasing to $122 per metric ton carbon equivalent in 2020 (Figure 12). This cost for CO_2 permits reflects the need to retire existing coal-fired capacity and switch to less carbon-intensive fuels, primarily natural gas. Currently, there are no economical technologies to sequester CO_2 emissions from coal plants. The cost for NO_x emission allowances is expected

Figure 9. Electricity Sales in Four Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 10. Projected Electricity Generation from Coal, Natural Gas, and Renewable Fuels (Excluding Cogenerators) in Four Cases, 2010 and 2020



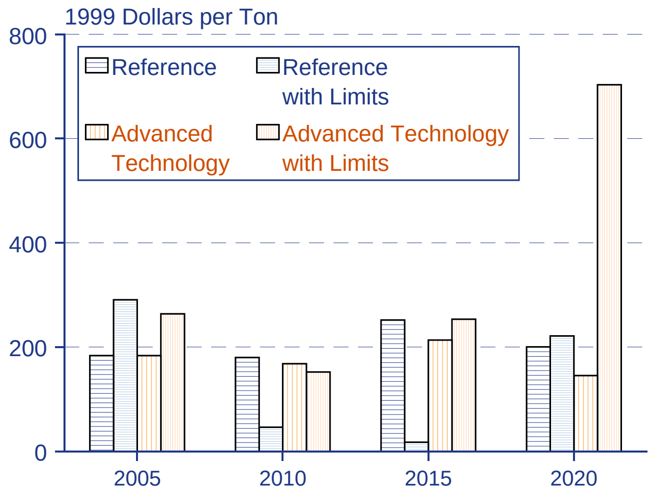
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

[21] See web site www.epa.gov/airmarkets/arp/.

to decline to zero by 2010 because the actions taken to meet the CO_2 limits result in NO_x emissions being within the specified limit (Figure 13). The Hg control costs are expected to be $482 million per ton in 2010 and $306 million per ton in 2020 (Figure 14). Although the unit cost of Hg removal is high, the total cost for reducing Hg emissions is small when compared with costs to reduce CO_2 emissions.

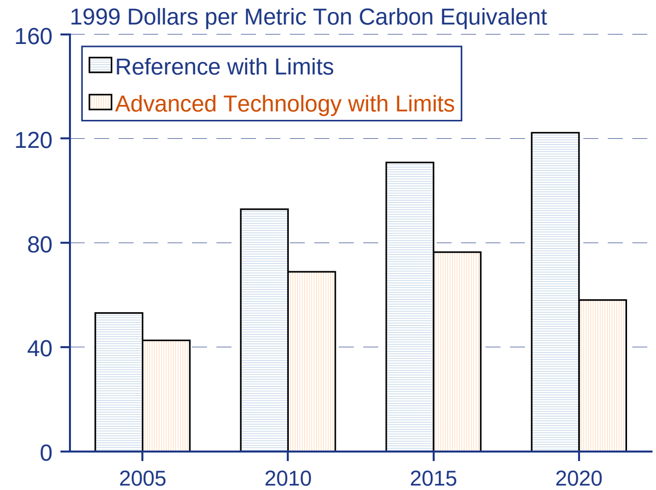
There are costs to power producers associated with electricity generation resulting from the emissions limits. The total cost of producing electric power includes the cost of fuels to generate electricity, operations and maintenance costs, investments in plants and equipment, and costs to purchase power from other generators. The sum of all these costs is called the resource cost. This resource cost is different from the marginal cost of generating electricity because it includes fixed costs, such as investments and portions of operations and maintenance costs, that do not vary based on production levels. Producers may not recover these fixed costs in competitive markets when the market price of electricity is at the same level as their marginal production costs, which only include fuel and certain other costs that vary with output levels. However, over time, producers need to recover their resource costs in order to remain in business. In the competitive marketplace which is assumed in these projections, a power producer would recover these costs during periods when the market price of power is higher than its production cost, for example,

Figure 11. Sulfur Dioxide Allowance Price in Four Cases, 2005-2020



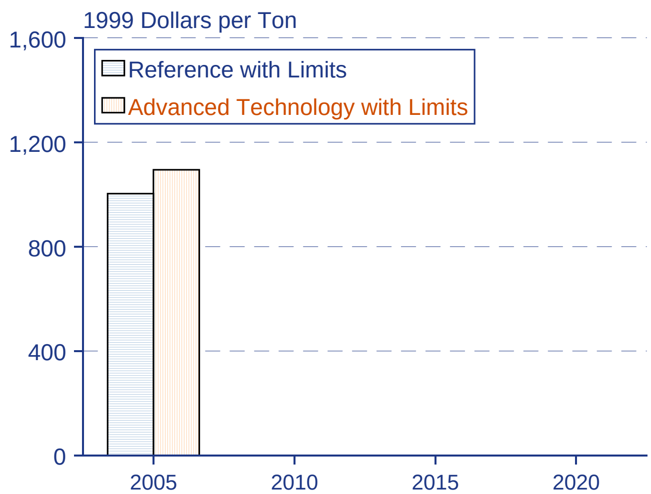
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Figure 12. Carbon Dioxide Allowance Price in Two Cases, 2005-2020



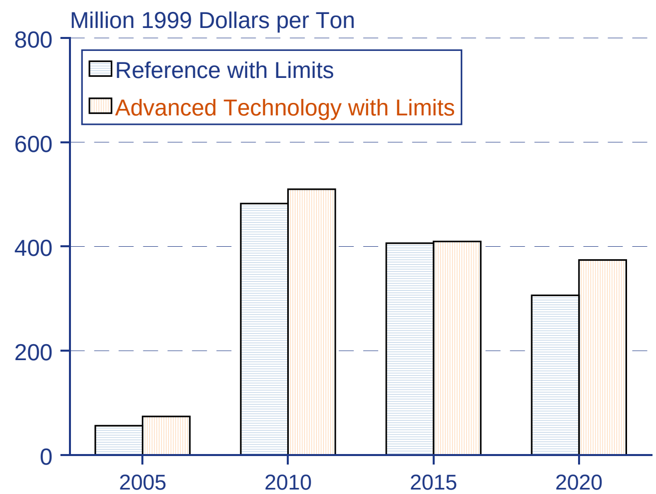
Source: National Energy Modeling System, runs SCENAEM.D081601A and SCENBEM.D081701A.

Figure 13. Nitrogen Oxides Allowance Price in Two Cases, 2005-2020



Source: National Energy Modeling System, runs SCENAEM.D081601A and SCENBEM.D081701A.

Figure 14. Mercury Allowance Price in Two Cases, 2005-2020



Source: National Energy Modeling System, runs SCENAEM.D081601A and SCENBEM.D081701A.

when a high-production-cost combustion turbine sets the market price while a low-production-cost pulverized coal unit is producing electricity.

For all the cases with emissions limits analyzed in this study, the resource costs are projected to be higher relative to the resource costs in the comparable cases without emissions limits. The largest increase is for fuels used to generate electricity. There are also costs associated with purchases of power from other generators and investment costs for new generation facilities or for retrofitting plants with emission control equipment.

From 2001 through 2020, the cumulative resource costs to generate electricity are expected to be $2,208 billion (undiscounted 1999 dollars) in the reference case with emissions limits, compared to $2,031 billion in the same case without the limits. Thus, the projected incremental cumulative expenditures attributable to emission limits that would be incurred by electricity generators is $177 billion, a 9-percent increase (Figure 15). These costs exclude the costs of emission permits that must be purchased by electricity generators because they are funds that are transferred among industry participants and do not represent actual resource consumption. The costs of the emissions permits are included in the delivered price of electricity, to the extent that they can be passed through to consumers.

In the reference case with emissions limits, the annualized resource costs in 2007 (the year the limits are fully imposed), which include financing and capital recovery costs, are $19.9 billion higher than projected in the reference case without limits. These incremental costs due to emissions limits are expected to be reduced to $19.1 billion and $18.1 billion in 2010 and 2020, respectively.

Natural Gas

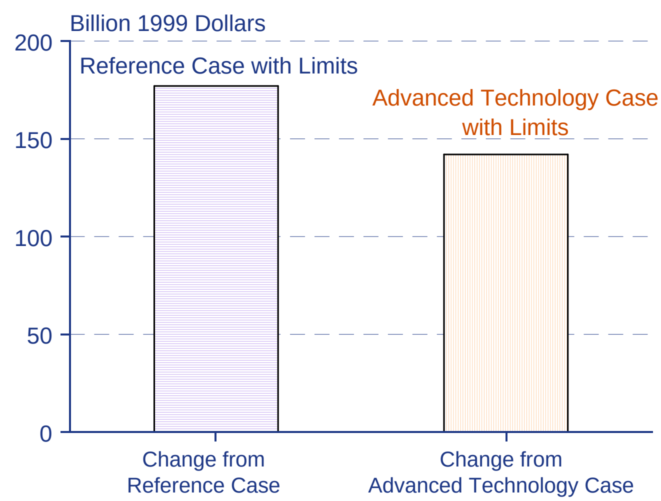
In the reference case, natural gas consumption is expected to increase at an average annual rate of 2.3 percent over the forecast horizon. By 2020, total natural gas consumption is expected to reach 35.0 trillion cubic feet, an increase of 61 percent from 1999 levels (Table 5). One of the fastest growing sectors for natural gas consumption is electricity generation. By 2020, the amount of natural gas consumed by electricity generators, excluding cogenerators, is expected to reach 11.2 trillion cubic feet, three times the volume used in 1999. In the next few years, natural gas prices are expected to decline from their record-high levels reached over the winter of 2001, dropping to $2.84 per thousand cubic feet at the wellhead by 2006. Although increased domestic production and imports keep pace with consumption, prices in the longer term rise as total demand grows, and wellhead prices are projected to reach $3.10 per thousand cubic feet by 2020 in the reference case.

Imposing emissions limits on electricity generators is expected to increase the demand for natural gas, during a period when the demand is already expected to be growing quickly. Because CO_2 emissions from natural gas are relatively low compared with other fossil fuels and natural gas is virtually free of SO_2 and Hg, electricity generators can help meet their emissions requirements by switching to natural gas. Imposing the limits on the reference case leads to higher natural gas demand by electricity generators. By 2020, the demand for natural gas by electricity generators is expected to reach 13.9 trillion cubic feet, 24 percent higher than the level of 11.2 trillion cubic feet projected in the case without emissions limits. Also, projected natural gas consumption in the commercial and industrial sectors is higher, primarily for cogeneration. As a result, total natural gas consumption in 2020 is projected to increase to 38.4 trillion cubic feet, compared to 35.0 trillion cubic feet in the reference case without emissions limits.

Higher natural gas demand results in higher prices. By 2020, the projected wellhead price reaches $3.72 per thousand cubic feet in the case with the emissions limits, compared to $3.10 per thousand cubic feet in the case without the limits (Figure 16). This results in higher natural gas prices for end users. Industrial prices, which are more closely tied to the wellhead price, are higher by 16 percent in 2020 compared to the reference case, while residential prices, which include more distribution costs, are higher by 8 percent.

The required increases in natural gas supply are met through higher imports and higher domestic production (Figure 17). Total net imports of natural gas are projected

Figure 15. Impacts of Emission Limits on Cumulative Resource Costs for Electricity Generation, 2001-2020



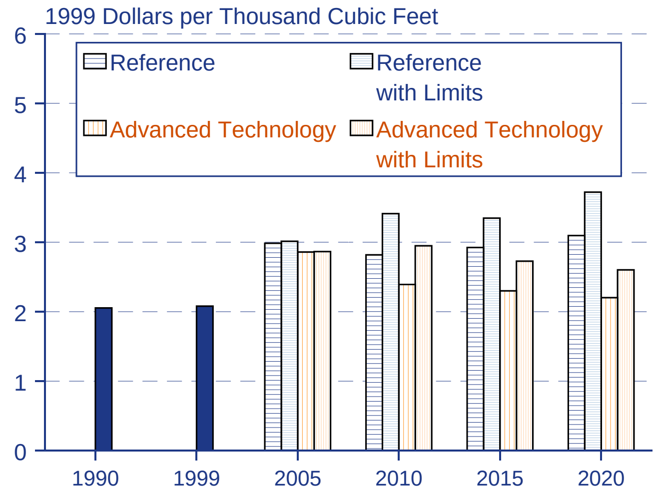
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

to be 2.1 trillion cubic feet higher in 2020 in the reference case with emissions limits than they are in the case without the limits, with most of the additional imports coming from Mexico or as liquefied natural gas from countries such as Algeria, Australia, and Qatar. About 0.3 trillion cubic feet of additional net imports are projected from Canada. Total domestic production in 2020 is projected to be 1.3 trillion cubic feet higher in the reference case with emissions limits than it is in the reference case without the limits. Increased unconventional natural gas production, which becomes more economic at the higher prices in the case with emissions limits, accounts for 0.9 trillion cubic feet of the additional domestic production.[22]

Coal

Primarily due to the CO_2 limits, projected coal consumption is sharply reduced from the level in the reference case when emissions limits are imposed. When the costs associated with acquiring CO_2 allowances are added to the delivered price of coal, the effective delivered price to generators is projected to triple relative to that in the reference case by 2010 and reaches $3.97 per million Btu in 2020, approximately four times the reference case price (Table 6). Due to CO_2 emissions reductions and measures taken to meet the Hg limit, coal-fired electricity generation is projected to lose a substantial share of the market to natural-gas-fired generation, compared with the share of coal-fired generation in the reference case. In addition, higher projected electricity prices cause total electricity sales to decline, reducing overall generation requirements.

Figure 16. Natural Gas Wellhead Price in Four Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Table 5. Natural Gas Market Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
		2010			
Average Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	2.82	3.41	2.39	2.95
Delivered Price to Electricity Generators (1999 Dollars per Thousand Cubic Feet)	2.62	3.30	4.18	2.87	3.70
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Thousand Cubic Feet)	2.62	3.30	5.55	2.87	4.71
Consumption by Electricity Generators, Excluding Cogenerators (Trillion Cubic Feet)	3.8	6.8	9.7	5.9	8.8
Total Consumption (Trillion Cubic Feet)	21.8	28.2	31.1	27.0	29.9
Domestic Production (Trillion Cubic Feet)	18.7	23.4	24.6	22.4	24.9
		2020			
Average Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	3.10	3.72	2.20	2.60
Delivered Price to Electricity Generators (1999 Dollars per Thousand Cubic Feet)	2.62	3.68	4.52	2.75	3.44
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Thousand Cubic Feet)	2.62	3.68	6.31	2.75	4.29
Consumption by Electricity Generators, Excluding Cogenerators (Trillion Cubic Feet)	3.8	11.2	13.9	9.1	11.9
Total Consumption (Trillion Cubic Feet)	21.8	35.0	38.4	32.4	35.6
Domestic Production (Trillion Cubic Feet)	18.7	29.3	30.7	27.3	30.1

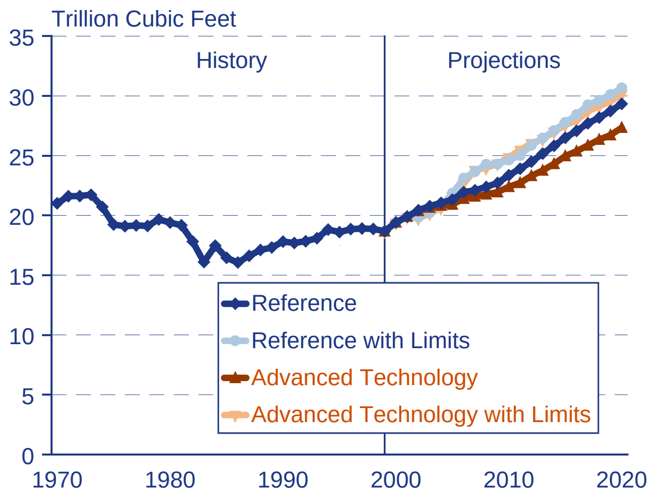
[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

[22]Unconventional natural gas includes low-permeability or tight sandstones, natural gas shales, and coalbed methane.

Because of lower installed coal-fired generation capacity and lower utilization of the remaining coal-fired capacity, projected coal consumption for electricity generation in 2020 is reduced to a level that is 43 percent of that in the reference case. Total coal production is projected to decline at a slower rate than the demand for coal in the electricity generation sector because, as a result of lower coal prices, consumption is projected to increase in other sectors not subject to the CO_2 limits, including industrial and coking coal and coal exports, assuming other countries do not impose new limits on coal consumption (Figure 18).

Figure 17. Natural Gas Production in Four Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Although CO_2 limits have the greatest impact on coal consumption, both SO_2 and Hg emissions limits are projected to add to the cost of using coal and contribute to further reductions in coal-fired generation. In 2020, an additional 20 gigawatts of scrubber retrofits are projected to be added to meet the more stringent emissions limits on SO_2 and Hg. The assumed technology costs for emissions removal are based on current estimates. Coal production is projected to be reduced in all regions and shift to sources with lower Hg content, such as mines located in the Rocky Mountains, and away from lignite and waste coal, which have relatively high Hg content.

End-Use Demand

Residential

Of all the cases analyzed in this report, emissions limits have the largest impact on residential energy prices in the reference case because it is the case with the highest

Table 6. Coal Market Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
2010					
Consumption by Electricity Generators, Excluding Cogenerators (Million Short Tons)	920	1,139	623	1,125	644
Production (Million Short Tons)	1,102	1,289	783	1,271	800
Minemouth Price (1999 Dollars per Short Ton)	17.13	14.19	14.63	12.73	13.40
Delivered Price to Electricity Generators (1999 Dollars per Million Btu)	1.21	1.06	0.98	0.98	0.93
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Million Btu)	1.21	1.06	3.35	0.98	2.69
Average SO_2 Content (Pounds per Million Btu)	2.0	1.8	1.8	1.8	1.8
Average Hg Content (Pounds per Trillion Btu)	7.7	7.3	6.1	7.2	6.1
CO_2 Allowance Cost (1999 Dollars per Million Btu)	0.00	0.00	2.37	0.00	1.76
2020					
Consumption by Electricity Generators, Excluding Cogenerators (Million Short Tons)	920	1,190	515	1,133	563
Production (Million Short Tons)	1,102	1,336	679	1,271	716
Minemouth Price (1999 Dollars per Short Ton)	17.13	12.93	12.61	10.76	10.97
Delivered Price to Electricity Generators (1999 Dollars per Million Btu)	1.21	0.98	0.84	0.85	0.78
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Million Btu)	1.21	0.98	3.97	0.85	2.26
Average SO_2 Content (Pounds per Million Btu)	2.0	1.7	1.8	1.7	1.8
Average Hg Content (Pounds per Trillion Btu)	7.7	7.1	6.2	7.1	6.0
CO_2 Allowance Cost (1999 Dollars per Million Btu)	0.00	0.00	3.12	0.00	1.48

[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

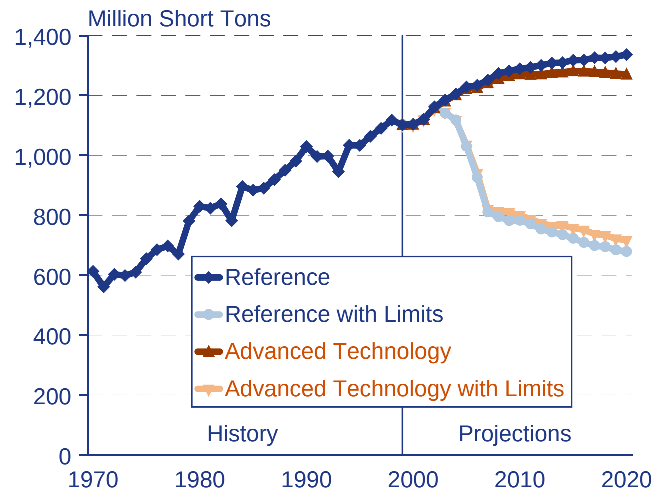
level of demand. The higher demand for energy, particularly electricity, in the reference case relative to all other cases causes projected generation costs to be higher with emissions limits, translating into higher end-use prices. Relative to the reference case, average residential energy prices are projected to be 17 percent higher in both 2010 and 2020 (Table 7). However, projected residential electricity prices are 25 and 26 percent higher in 2010 and 2020, respectively. The higher prices in the case with emissions limits are projected to reduce residential energy demand, as consumers react to the higher prices by purchasing more efficient appliances and reducing their demand for energy services (Figure 19).

Since residential electricity prices are projected to increase more than the other fuels as a result of the emissions limits, the projected demand for electricity shows the largest decrease, as consumers switch to other fuels for their heating needs and overall appliance efficiency increases for electric equipment, such as air conditioners. The projected reduction in electricity demand is reflected in reduced CO_2 emissions attributed to energy use in the residential sector. Of the projected CO_2 reduction of 76 million metric tons carbon equivalent in the residential sector in the case with emissions limits in 2010, virtually all is attributed to the projected decrease in electricity demand. In 2020, the projected residential CO_2 emissions are reduced by 102 million metric tons carbon equivalent, or 27 percent, relative to the reference case.

Commercial

The imposition of emissions limits in the reference case results in a 4-percent reduction in projected commercial delivered energy use in 2010, with electricity accounting for 74 percent of the projected decrease (Table 8). In 2020, commercial energy demand is projected to be reduced by 2 percent, relative to the reference case. The cost of

Figure 18. Coal Production in Four Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

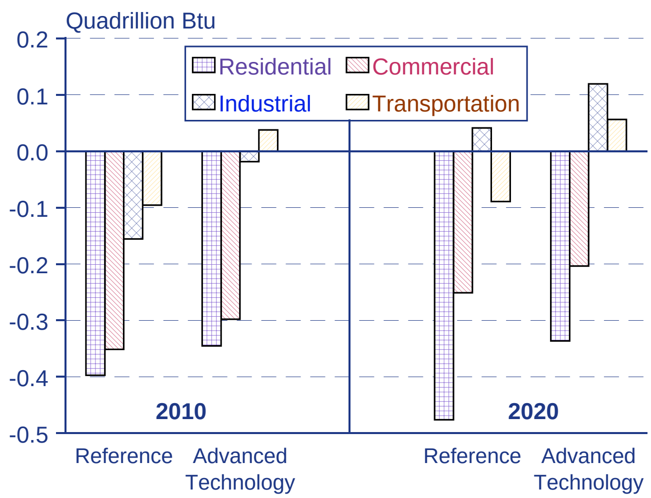
Table 7. Residential Sector Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
		2010			
Delivered Energy Consumption (Quadrillion Btu)	10.7	12.2	11.8	11.8	11.4
Electricity	3.9	4.9	4.6	4.8	4.6
Natural Gas	4.9	5.5	5.5	5.3	5.2
Petroleum	1.4	1.3	1.3	1.2	1.2
Average Delivered Prices (1999 Dollars per Million Btu)	13.18	13.41	15.70	13.12	14.99
Electricity	23.69	22.19	27.74	21.55	25.86
Natural Gas	6.52	6.70	7.22	6.38	6.88
Petroleum	7.55	9.37	9.45	9.28	9.26
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	290	346	270	334	265
		2020			
Delivered Energy Consumption (Quadrillion Btu)	10.7	13.5	13.0	12.8	12.4
Electricity	3.9	5.7	5.3	5.6	5.3
Natural Gas	4.9	6.1	6.0	5.7	5.6
Petroleum	1.4	1.2	1.3	1.1	1.1
Average Delivered Prices (1999 Dollars per Million Btu)	13.18	13.62	16.00	12.67	14.15
Electricity	23.69	22.16	27.83	20.41	23.66
Natural Gas	6.52	6.56	7.11	5.79	6.21
Petroleum	7.55	9.47	9.48	9.23	9.22
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	290	383	281	357	274

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

complying with emissions limits causes projected commercial electricity prices to be 33 percent higher in 2010 and 34 percent higher in 2020, compared to the reference case, while average natural gas prices to the sector are projected to be higher by 9 percent and 10 percent in 2010 and 2020, respectively, as electricity generators turn to natural gas to minimize their compliance costs. Commercial consumers are expected to minimize their own energy costs in the case with emissions limits through measures such as shutting off lights and equipment while not in use and by purchasing more efficient equipment.

Figure 19. Impacts of Emission Limits on Delivered Energy Consumption in Two Cases, 2010 and 2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

In this analysis, commercial sector distributed generation resources are assumed to be exempt from the emissions limits imposed on the electricity generation sector because they are typically small systems. Because electricity prices increase much more dramatically than natural gas prices, commercial consumers are expected to generate more electricity to meet their own requirements, producing more than twice as much electricity using natural-gas-fired distributed generation technologies in 2010 and about six times as much in 2020 in the case with emissions limits. Although water and space heating needs are met using some of the heat produced when generating electricity, additional natural gas is required to fuel distributed generation resources. CO_2 emissions reductions attributed to purchased electricity are projected to be 74 million metric tons carbon equivalent in 2010 and 102 million metric tons carbon equivalent in 2020. Total projected commercial sector CO_2 emissions are reduced by 75 million metric tons carbon equivalent, or 24 percent, in 2010 and by 99 million metric tons carbon equivalent, or 29 percent, in 2020.

Industrial

Imposing emissions limits on the electric generation sector has essentially no impact on total delivered industrial energy consumption in the reference case because

Table 8. Commercial Sector Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
		2010			
Delivered Energy Consumption (Quadrillion Btu)	**7.5**	**9.9**	**9.5**	**9.8**	**9.5**
Electricity	3.7	4.9	4.6	4.8	4.6
Natural Gas	3.1	4.2	4.1	4.2	4.1
Petroleum	0.6	0.6	0.6	0.6	0.6
Average Delivered Prices (1999 Dollars per Million Btu)	**13.28**	**12.23**	**15.33**	**11.50**	**14.02**
Electricity	21.64	18.76	24.94	17.76	22.67
Natural Gas	5.34	5.63	6.15	5.26	5.77
Petroleum	4.99	6.27	6.27	6.14	6.11
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**242**	**315**	**240**	**309**	**241**
		2020			
Delivered Energy Consumption (Quadrillion Btu)	**7.5**	**10.9**	**10.6**	**10.9**	**10.7**
Electricity	3.7	5.6	5.2	5.5	5.2
Natural Gas	3.1	4.5	4.7	4.6	4.7
Petroleum	0.6	0.6	0.6	0.6	0.6
Average Delivered Prices (1999 Dollars per Million Btu)	**13.28**	**12.55**	**15.54**	**10.89**	**12.61**
Electricity	21.64	18.83	25.32	16.56	20.14
Natural Gas	5.34	5.67	6.21	4.84	5.26
Petroleum	4.99	6.37	6.32	6.17	6.14
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**242**	**347**	**248**	**331**	**250**

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

the industrial sector chooses to generate more of its own electricity (which is assumed to be exempt from the emissions limits), primarily from natural gas, accounting for a slight increase in total industrial energy consumption. While total delivered energy consumption is not significantly affected by the emissions limits, the fuel mix is altered. The projected industrial electricity price in 2010 is 40 percent higher than in the reference case due to the emissions limits and 43 percent higher in 2020 (Table 9). As a result, purchased electricity consumption is projected to be lower by 7 percent, or 0.3 quadrillion Btu, relative to the reference case in 2010 and by 13 percent, or 0.6 quadrillion Btu in 2020. At the same time, consumption of both petroleum products and natural gas is projected to be higher. Projected cogeneration from natural gas is higher by 61 percent in 2010 and 128 percent in 2020 compared to the reference case without emissions limits.[23]

CO_2 emissions attributable to the industrial sector are reduced by 62 million metric tons carbon equivalent, or 12 percent, in 2010 and by 83 million metric tons carbon equivalent, or 14 percent, in 2020. The CO_2 reductions result from the reduction in purchased electricity.

Transportation

In the reference case, transportation energy use increases at an average annual rate of 1.8 percent through 2020, with light-duty vehicles accounting for 57 percent of total transportation energy use in 2020 (Table 10). Growth in travel by all modes combined with modest fuel efficiency improvements causes the transportation sector to have the fastest projected growth of all the end-use sectors.

Petroleum-based fuels account for 96 percent of total transportation demand in 2020. Because the transportation sector is almost entirely dependent on petroleum, the emissions limits on electricity generators and the subsequent impact on natural gas and coal markets have little impact on the sector. Applying the emissions limits to the reference case causes no significant changes in efficiency or travel demand with the exception of rail and natural gas pipeline shipments, which are correlated with coal and natural gas consumption. As a result of projected changes in fuel utilization by electricity generators, reduced coal shipments are projected to lower rail travel by 18 percent and subsequent energy use by 16 percent in 2020 (Table 11). The higher demand for natural gas is projected to raise pipeline energy use by 5 percent in 2020, relative to the reference case. Overall, there is a slight reduction in transportation energy use, about 0.1 quadrillion Btu in both 2010 and 2020. Projected CO_2 emissions from the transportation sector are reduced by 3 and 5 million metric tons carbon equivalent in 2010 and 2020, respectively, less than 1 percent.

AEO2001 High Technology Assumptions

The *AEO2001* reference case assumes continued improvements in technology for both energy consumption and production. As noted in Chapter 1, the residential, commercial, transportation, electricity generation, and refining sectors of NEMS explicitly represent individual energy-consuming technologies and their characteristics. Equipment choices are made for individual technologies as new equipment is needed to meet growing demand for energy services or to replace retired equipment. Technologies are chosen based on the overall costs relative to competing technologies, subject to assumptions about consumer choice and implied hurdle rates as derived from existing data. In the industrial demand sector, technology improvements for the major processing steps or end uses for the energy-intensive industries are represented by technology possibility curves of efficiency improvements over time. Due to data limitations and the heterogenous nature of the industrial sector, it is impractical to represent individual technologies in the same manner as in the other end-use demand sectors. However, industrial cogeneration capacity additions are based on an explicit representation of technology cost and performance.

Similar to the industrial sector, technology improvements for fossil fuel supply are also represented, but in a less detailed manner. In the oil and gas supply sector, technology progress for exploration and production activities is represented by annual improvements in finding rates, success rates, and drilling, lease equipment and operating costs, in accordance with historical trends. Significant improvements in exploration and production, such as three-dimensional seismology and horizontal drilling and completion, have served to reduce the cost of oil and gas supply activities. Technological advances in the coal industry, such as improvements in coal haulage systems at underground mines, contribute to increases in productivity, as measured in average short tons of coal per miner per hour. Productivity improvements are assumed to continue but to moderate in magnitude over the forecast horizon.

AEO2001 presents a range of alternative cases that vary key assumptions about technology improvement and penetration.[24] For the end-use demand and electricity

[23]Total industrial output includes oil and gas production, coal mining, and refining. Consequently, the value of total industrial output may increase in the cases with emissions limits.

[24]Energy Information Administration, *Assumptions to the Annual Energy Outlook 2001*, DOE/EIA-0554(2001)(Washington, DC, December 2001), web site www.eia.doe.gov/oiaf/fore_pub.html.

generation sectors, a more rapid pace of technology improvements in energy-consuming equipment is projected to reduce energy consumption and encourage more advanced fossil-fired and renewable technologies than in the reference case. In the end-use demand sectors, experts in technology engineering were consulted to derive high technology assumptions, considering the potential impacts of increased research and development for more advanced technologies.[25] It is possible that even further technology improvements

Table 9. Industrial Sector Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
		2010			
Industrial Output (Billion 1992 Dollars)	4,722	6,223	6,212	6,217	6,217
Industrial Output Growth (Annual Percent, 1999-2010)	—	2.54	2.52	2.53	2.53
Delivered Energy Consumption (Quadrillion Btu)	27.6	31.1	31.0	30.7	30.7
Petroleum	9.5	10.5	10.6	10.2	10.4
Natural Gas	9.8	11.3	11.3	11.2	11.2
Coal	2.5	2.6	2.5	2.5	2.4
Renewables	2.2	2.6	2.6	2.8	2.8
Purchased Electricity	3.6	4.2	3.9	4.0	3.8
Delivered Energy Intensity (Thousand Btu per 1992 Dollar of Output)	5.84	5.00	4.99	4.94	4.93
Change in Delivered Energy Intensity (Annual Percent, 1999-2010)	—	-1.39	-1.42	-1.51	-1.51
Average Delivered Prices (1999 Dollars per Million Btu)	5.29	5.62	6.50	5.27	5.98
Electricity	13.12	12.04	16.84	11.29	15.13
Natural Gas	2.79	3.46	4.02	3.07	3.60
Petroleum	5.54	6.07	6.16	5.91	5.92
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	480	533	471	515	462
		2020			
Industrial Output (Billion 1992 Dollars)	4,722	8,083	8,098	8,069	8,068
Industrial Output Growth (Annual Percent, 1999-2020)	—	2.59	2.60	2.58	2.58
Delivered Energy Consumption (Quadrillion Btu)	27.6	34.7	34.8	33.8	33.9
Petroleum	9.5	11.6	11.7	11.0	11.2
Natural Gas	9.8	12.7	13.2	12.4	12.8
Coal	2.5	2.6	2.6	2.3	2.3
Renewables	2.2	3.1	3.1	3.6	3.6
Purchased Electricity	3.6	4.8	4.1	4.5	4.0
Delivered Energy Intensity (Thousand Btu per 1992 Dollar of Output)	5.84	4.30	4.29	4.18	4.20
Change in Delivered Energy Intensity (Annual Percent, 1999-2020)	—	-1.45	-1.45	-1.57	-1.56
Average Delivered Prices (1999 Dollars per Million Btu)	5.29	5.82	6.60	5.08	5.55
Electricity	13.12	12.07	17.30	10.36	13.39
Natural Gas	2.79	3.73	4.32	2.88	3.30
Petroleum	5.54	6.12	6.13	5.85	5.80
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	480	585	502	543	478

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

[25]Buildings: Energy Information Administration (EIA), *Technology Forecast Updates—Residential and Commercial Building Technologies* (Arthur D. Little, Inc., September 1998) and EIA, *Technology Forecast Updates—Residential and Commercial Building Technologies—Advanced Adoption Case* (Arthur D. Little, Inc., September 1998). Industrial: EIA, *Aggressive Technology Strategy for the NEMS Model* (Arthur D. Little, Inc., September 1998). Transportation: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond*, ORNL / CON-444 (Washington, DC, September 1997); Office of Energy Efficiency and Renewable Energy, Office of Transportation Technologies, *OTT Program Analysis Methodology: Quality Metrics 2000* (November 1998); J. DeCicco and M. Ross, *An Updated Assessment of the Near-Term Potential for Improving Automotive Fuel Economy* (Washington, DC: American Council for an Energy-Efficient Economy, November 1993); and F. Stodolsky, A. Vyas, and R. Cuenca, *Heavy and Medium Duty Truck Fuel Economy and Market Penetration Analysis, Draft Report* (Chicago, IL: Argonne National Laboratory, August 1999).

Table 10. Transportation Energy Consumption in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference: Without Emissions Limits	Reference: With Emissions Limits	Advanced Technology: Without Emissions Limits	Advanced Technology: With Emissions Limits
		2010			
Energy Use by Mode (Quadrillion Btu)					
Light-Duty Vehicle	15.5	19.2	19.1	18.0	18.0
Heavy-Duty Vehicle	4.5	5.8	5.8	5.6	5.6
Air	3.5	4.6	4.5	4.5	4.6
Rail	0.6	0.7	0.6	0.6	0.6
Marine	1.3	1.5	1.5	1.5	1.5
Pipeline Fuel	0.7	0.9	1.0	0.9	1.0
Lubricants	0.2	0.3	0.3	0.3	0.3
Total	**26.3**	**32.8**	**32.7**	**31.3**	**31.3**
Energy Use by Fuel Type (Quadrillion Btu)					
Motor Gasoline	15.9	18.9	18.9	17.9	17.9
Distillate	5.1	7.0	6.9	6.6	6.5
Jet Fuel	3.5	4.5	4.5	4.5	4.5
Residual Fuel	0.7	0.9	0.9	0.9	0.9
Other Petroleum	0.3	0.4	0.4	0.4	0.4
Petroleum Subtotal	*25.5*	*31.6*	*31.5*	*30.2*	*30.1*
Methanol (M85)	0.00	0.00	0.01	0.00	0.01
Ethanol (E85)	0.01	0.03	0.03	0.05	0.05
Electricity	0.06	0.12	0.12	0.09	0.09
Compressed Natural Gas	0.02	0.09	0.09	0.13	0.13
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00
Pipeline Fuel	0.7	0.9	1.0	0.9	1.0
Total	**26.3**	**32.8**	**32.7**	**31.3**	**31.3**
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**498**	**626**	**623**	**597**	**596**
		2020			
Energy Use by Mode (Quadrillion Btu)					
Light-Duty Vehicle	15.5	21.7	21.7	18.8	18.8
Heavy-Duty Vehicle	4.5	6.7	6.7	6.2	6.2
Air	3.5	6.0	6.0	5.9	5.9
Rail	0.6	0.7	0.6	0.6	0.6
Marine	1.3	1.5	1.5	1.5	1.5
Pipeline Fuel	0.7	1.1	1.2	1.0	1.1
Lubricants	0.2	0.3	0.3	0.3	0.3
Total	**26.3**	**38.2**	**38.1**	**34.3**	**34.4**
Energy Use by Fuel Type (Quadrillion Btu)					
Motor Gasoline	15.9	21.3	21.2	18.4	18.4
Distillate	5.1	8.2	8.1	7.3	7.3
Jet Fuel	3.5	6.0	6.0	5.8	5.8
Residual Fuel	0.7	0.9	0.9	0.9	0.9
Other Petroleum	0.3	0.4	0.4	0.5	0.5
Petroleum Subtotal	*25.5*	*36.7*	*36.6*	*32.9*	*32.9*
Methanol (M85)	0.00	0.00	0.00	0.01	0.00
Ethanol (E85)	0.01	0.04	0.04	0.07	0.07
Electricity	0.06	0.17	0.17	0.12	0.12
Compressed Natural Gas	0.02	0.16	0.15	0.22	0.21
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00
Pipeline Fuel	0.7	1.1	1.2	1.0	1.1
Total	**26.3**	**38.2**	**38.1**	**34.3**	**34.4**
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**498**	**730**	**725**	**653**	**652**

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

beyond those assumed in the high technology case could occur if there were a very aggressive research and development effort.

The revised assumptions include earlier years of introduction, lower costs, higher maximum market potential, or higher efficiencies than assumed in the reference case or a combination of these assumptions. In addition, in the residential sector, existing building shell efficiencies are assumed to improve by 15 percent over 1997 levels by 2010, and commercial building shell efficiencies are assumed to increase 50 percent faster than in the reference case. In the industrial sector, more rapid technology is implemented by increasing the rate of energy intensity decline for the processes and end uses in the process and assembly component of the industrial model, as presented in Appendix B. In addition, recovery of by-product biomass is assumed to grow more rapidly in the high technology case, 1 percent per year compared with 0.2 percent per year in the reference case. Since the impact of improved technology is amplified if existing equipment is retired more quickly, the industrial high technology case also assumes more rapid retirement rates.

Although more advanced technologies may reduce energy consumption, in general they are more expensive when initially introduced. In order to penetrate into the market, advanced technologies must be purchased by consumers; however, many potential purchasers may not be willing to buy more expensive equipment that has a long period for recovering the additional cost through energy savings, and many consumers may value other attributes more than energy efficiency. Penetration can also be slowed by the turnover of the capital stock.

Table 11. Transportation Efficiency and Travel in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference		Advanced Technology	
		Without Emissions Limits	With Emissions Limits	Without Emissions Limits	With Emissions Limits
		2010			
Energy Efficiency Indicators					
New Light-Duty Vehicle (Miles per Gallon)	24.2	27.2	27.3	31.9	31.8
New Car (Miles per Gallon)	27.9	32.5	32.5	36.3	36.2
New Light Truck (Miles per Gallon)	20.8	23.3	23.4	28.3	28.3
Light-Duty Fleet (Miles per Gallon)	20.5	21.0	21.0	22.3	22.3
Aircraft Efficiency (Seat Miles per Gallon)	51.7	56.1	56.1	56.1	56.1
Freight Truck Efficiency (Miles per Gallon)	6.0	6.4	6.4	6.7	6.7
Rail Efficiency (Ton Miles per Thousand Btu)	2.8	3.1	3.1	3.3	3.3
Domestic Shipping (Ton Miles per Thousand Btu)	2.3	2.7	2.7	2.7	2.7
Travel					
Light-Duty Vehicle (Billion Miles)	2,394	3,059	3,053	3,072	3,073
Heavy-Duty Vehicle (Billion Miles)	204	279	278	278	278
Air (Billion Seat Miles)	1,099	1,586	1,582	1,586	1,587
Rail (Billion Ton Miles)	1,353	1,708	1,450	1,701	1,462
Domestic Shipping (Billion Ton Miles)	661	778	756	771	765
		2020			
Energy Efficiency Indicators					
New Light-Duty Vehicle (Miles per Gallon)	24.2	28.1	28.1	34.9	34.8
New Car (Miles per Gallon)	27.9	32.5	32.5	39.1	39.0
New Light Truck (Miles per Gallon)	20.8	24.7	24.7	31.4	31.4
Light-Duty Fleet (Miles per Gallon)	20.5	21.5	21.6	25.1	25.1
Aircraft Efficiency (Seat Miles per Gallon)	51.7	60.3	60.3	61.8	61.8
Freight Truck Efficiency (Miles per Gallon)	6.0	6.9	6.9	7.5	7.5
Rail Efficiency (Ton Miles per Thousand Btu)	2.8	3.4	3.4	3.8	3.8
Domestic Shipping (Ton Miles per Thousand Btu)	2.3	3.0	3.0	3.2	3.2
Travel					
Light-Duty Vehicle (Billion Miles)	2,394	3,575	3,573	3,597	3,599
Heavy-Duty Vehicle (Billion Miles)	204	352	352	352	351
Air (Billion Seat Miles)	1,099	2,316	2,316	2,318	2,318
Rail (Billion Ton Miles)	1,353	1,967	1,611	1,932	1,633
Domestic Shipping (Billion Ton Miles)	661	890	861	873	869

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

To represent more rapid technology development in the electricity generation sector, the costs and efficiencies of advanced fossil-fired and new renewable generating technologies are assumed to improve from reference case values, based on assessments from the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy, DOE Office of Fossil Energy, and the Electric Power Research Institute.[26] For nuclear power plants, the reference case assumes that operating costs will increase after the plant reaches 30 years of age, at which point they increase by $0.25 per kilowatt per year for the next ten years, then by $13.50 per kilowatt per year for the next ten years. After 50 years of age, costs increase by about $25 per kilowatt per year. After 30 years of operation, the operating costs are evaluated every ten years, and the plant continues in operation if the operating costs are lower than the cost of building new capacity. For the high technology case in *AEO2001*, these aging-related cost increases are assumed to be 25 percent of those in the reference case.

For central station renewable generating technologies, capital costs in the high technology case are reduced so that, by 2020, they are the lower of either 15 percent below the reference case or approximately the costs specified by the DOE Office of Energy Efficiency and Renewable Energy and the Electric Power Research Institute in their joint 1997 report *Renewable Energy Technology Characterizations*.[27] Fixed operations and maintenance costs for renewable energy technologies are assumed to be lower than in the reference case and are designed to approximate costs in the same report. Lower capital costs are also assumed for residential and commercial photovoltaic systems. Higher capacity factors are assumed for wind and solar thermal central station generating capacity, reaching an average of 47 percent for wind power by 2020 compared with 38 percent in the reference case and 77 percent for solar thermal compared with 42 percent in the reference case. Finally, biomass energy supplies are assumed to be 10 percent higher than in the reference case, lowering the cost of biomass technologies through lower fuel costs.

For fossil fuel supply, assumptions of more rapid technology and productivity improvements increase the supplies and reduce the production costs. For conventional oil and natural gas supply, reference case parameters for the effects of technological progress on finding rates, drilling, lease equipment and operating costs, and success rates are increased by 25 percent. For unconventional natural gas, key exploration and production technologies are also increased by 25 percent. For enhanced oil recovery, cost reductions for drilling, completing, and equipping production wells and the penetration of horizontal well technology are also assumed to increase over reference case levels. The undiscovered recoverable resource base for natural gas miscible recovery is assumed to increase over the forecast period with advances in technology. Canadian supply parameters are adjusted to simulate the assumed impacts of rapid oil and natural gas technology development on Canadian supply. Although more rapid technology development increases the domestic supply potential of crude oil, oil prices are assumed to be set on world markets and are not affected by the technology improvements.[28] Natural gas production is higher and prices are reduced with more rapid technology improvements.

More rapid technology development in coal production is represented by increasing labor productivity and reducing labor and equipment costs, relative to the reference case. In 2020, national labor productivity, measured as short tons per miner per hour, increases from 10.22 in the reference case to 14.12 in the more rapid technology development case, reflecting a 4.0-percent increase in the annual labor productivity growth rate at underground coal mines and a 3.6-percent increase at surface coal mines. Labor wage rates for coal mine production workers and equipment costs are assumed to decline by 0.5 percent per year in real terms in the high technology case but remain constant in real terms in the reference case.

In general, more rapid development for advanced energy-consuming technologies will tend to encourage the adoption and penetration of these technologies, reducing energy consumption, improving energy efficiency, and increasing the use of more advanced technologies, relative to the reference case. However, consumers continue to make decisions concerning the adoption of these technologies in the same fashion, so these technologies must still be cost effective to penetrate the market.

All of these assumptions for more rapid improvements in technology are based on higher levels of research and development funding than assumed in the reference case and result in the successful development of the technologies. More rapid technology development could be possible with higher funding or breakthrough developments. The levels of funding necessary for the successful achievement of the technology characteristics

[26]Fossil-fired generating technologies: U.S. Department of Energy, Office of Fossil Energy. Renewable Generating Technologies: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, and Electric Power Research Institute, *Renewable Energy Technology Characterizations*, EPRI-TR-109496 (Washington, DC, December 1997).

[27]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, and Electric Power Research Institute, *Renewable Energy Technology Characterizations*, EPRI-TR-109496 (Washington, DC, December 1997).

[28]For this study, the potential for worldwide technology improvements in oil production was not addressed.

assumed in the advanced technology case are not known, nor are the environmental benefits quantified. The simultaneous success of all technology research would seem unlikely. History has shown that research and development funding levels cannot be directly tied to the successful development of new technologies. Since the reference case of *AEO2001* is based on historical levels of funding and technology development, the technology trends assumed in the reference case are considered to be the most likely trends.

AEO2001 presents a high technology case that combines the high technology assumptions in the energy-consuming sectors, both end-use demand and electricity generation by fossil fuels and renewables. However, the request by Senators Jeffords and Lieberman specified an advanced technology case that includes all demand and supply sectors. The introduction of more rapid technology improvements for oil and natural gas supply and higher productivity improvements and cost reductions for coal supply tend to reduce the prices of these fossil fuels. Lower prices for coal and natural gas, combined with technology improvements in electricity generation by fossil fuels and renewable sources and lower nuclear costs, will tend to lower the price of electricity. Reduced prices for coal, natural gas, and electricity are likely to discourage the adoption of the more efficient and advanced technologies to some degree by making them less cost effective than they otherwise would be.

In this advanced technology case, the projected average wellhead price of natural gas reaches $2.20 per thousand cubic feet in 2020, compared with $2.71 per thousand cubic feet in the advanced technology case without the improved technology for fuel supply (Table 12). The projected average minemouth price of coal is reduced from $12.83 per short ton in 2020 in the advanced technology case without fuel supply improvements to $10.76 per short ton, and projected average delivered electricity prices are reduced from 5.8 cents per kilowatthour to 5.5 cents per kilowatthour. In the advanced technology case, these lower prices have the effect of raising total energy consumption in 2020 by 1 percent to 120.4 quadrillion Btu, compared with 119.3 quadrillion Btu in the case without the fuel supply technology improvements. Electricity demand in 2020 is raised from 4,581 to 4,610 billion kilowatthours, or 1 percent. This rebound effect of lower fuel prices on energy consumption, while noticeable, is small and does not significantly impact the costs of the emissions reductions in this analysis.

Impact of Advanced Technology Assumptions on Energy Markets

As a result of the more rapid assumed technology development, total energy consumption in 2020 is projected to be reduced by 7 quadrillion Btu, or 6 percent, compared to the reference case, due to the earlier adoption of more efficient technologies in the end-use demand sectors. The primary energy intensity of the economy is projected to decline at an average annual rate of 1.9 percent between 1999 and 2020, compared to 1.6 percent in the reference case. Projected consumption of all fossil fuels and electricity is lower compared to the reference case; however, the use of existing nuclear power and renewable technologies is higher due to the assumed cost and performance improvements. Because of reduced energy consumption and the shift in the fuel mix to more renewables and nuclear power, projected CO_2 emissions in 2020 are reduced by 160 million metric tons carbon equivalent, or 8 percent, compared to the reference case.

Partly due to lower projected consumption but primarily due to the more rapid technology development assumed for the production of fossil fuels, the prices of both natural gas and coal are expected to be lower in the advanced technology case compared to the reference case. In 2020, the wellhead price of natural gas is expected to be $2.20 per thousand cubic feet in the advanced technology case, compared to $3.10 per thousand cubic feet in the reference case. The projected minemouth price of coal in 2020 is projected to be $10.76 per short ton and $12.93 per short ton in the advanced technology and reference cases, respectively. Since the price of crude oil is assumed to be set on world markets, the projected price of oil does not change. Lower projected prices for natural gas and coal, combined with lower electricity demand that reduces the need for new capacity, contribute to lower electricity prices. The average delivered price of electricity in 2020 is projected to be 5.5 cents per kilowatthour in the advanced technology case compared to 6.1 cents per kilowatthour in the reference case. As a result of lower projected prices and demand, energy expenditures are also lower.

End-Use Demand

Residential

Incorporating the advanced technology assumptions allows consumers to choose more efficient appliances at lower costs, relative to the reference case. Although average energy prices are projected to be lower by more than 2 percent relative to the reference case in 2010 and by 7 percent in 2020, projected residential energy demand is nearly 4 percent and 5 percent lower in 2010 and 2020, respectively, due to the advanced technology assumptions. Natural gas accounts for more than half of the reduction, as average building shell efficiency is projected to be nearly 10 percent higher than in the reference case in 2010 and 16 percent higher in 2020, reducing the amount of energy needed for space heating. Increases in building shell efficiency are driven by the adoption of more energy-efficient construction materials as well as an increase in awareness and familiarity of energy-efficient construction practices on the part of builders.

Table 12. Summary of Energy Market Projections in the Reference and Advanced Technology Cases, 2010 and 2020

Projections	1999	Reference	Advanced Technology Without Fuel Supply Technology Improvements	Advanced Technology With Fuel Supply Technology Improvements
		2010		
Production (Quadrillion Btu)	**73.3**	**80.9**	**79.8**	**80.7**
Petroleum	15.1	14.6	14.4	15.0
Natural Gas	19.2	24.0	22.9	23.0
Coal	23.1	26.5	26.0	26.1
Nuclear Power	7.8	7.7	7.7	8.0
Renewable Energy	6.5	7.9	8.3	8.2
Primary Energy Consumption (Quadrillion Btu)	**96.3**	**114.7**	**111.5**	**111.7**
Petroleum	37.9	44.3	42.4	42.4
Natural Gas	22.3	28.9	27.7	27.7
Coal	21.4	25.6	25.1	25.1
Nuclear Power	7.8	7.7	7.7	8.0
Renewable Energy	6.5	7.9	8.3	8.2
Change in Primary Energy Intensity (Annual Percent Change, 1999-2010)	**—**	**-1.6**	**-1.9**	**-1.8**
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,133**	**4,041**	**4,049**
Prices				
World Oil Price (1999 Dollars per Barrel)	17.22	21.37	21.37	21.37
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	2.82	2.52	2.39
Coal Minemouth Price (1999 Dollars per Short Ton)	17.13	14.19	13.92	12.73
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.1	5.9	5.9
CO_2 Emissions[a] (Million Metric Tons Carbon Equivalent)	**1,511**	**1,821**	**1,754**	**1,755**
		2020		
Production (Quadrillion Btu)	**73.3**	**87.6**	**84.0**	**86.3**
Petroleum	15.1	15.2	14.6	15.5
Natural Gas	19.2	30.1	27.7	28.1
Coal	23.1	27.1	26.2	25.9
Nuclear Power	7.8	6.5	5.8	7.2
Renewable Energy	6.5	8.4	9.1	9.1
Primary Energy Consumption (Quadrillion Btu)	**96.3**	**127.7**	**119.3**	**120.4**
Petroleum	37.9	50.4	45.8	45.7
Natural Gas	22.3	35.9	33.1	33.2
Coal	21.4	26.3	25.3	25.1
Nuclear Power	7.8	6.5	5.8	7.2
Renewable Energy	6.5	8.4	9.1	9.1
Change in Primary Energy Intensity (Annual Percent Change, 1999-2020)	**—**	**-1.6**	**-1.9**	**-1.9**
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,763**	**4,581**	**4,610**
Prices				
World Oil Price (1999 Dollars per Barrel)	17.22	22.41	22.41	22.41
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	3.10	2.71	2.20
Coal Minemouth Price (1999 Dollars per Short Ton)	17.13	12.93	12.83	10.76
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.1	5.8	5.5
CO_2 Emissions[a] (Million Metric Tons Carbon Equivalent)	**1,511**	**2,044**	**1,891**	**1,884**

[a]CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENBBS.D080301A, and SCENB1BS.D080301A.

Residential electricity demand, which is projected to grow faster than any other fuel over the projection period, is reduced by 1 percent relative to the reference case in 2010 and by 2 percent in 2020. Most electric appliances available to the residential sector are considered "mature," and thus gains in efficiency due to the adoption of advanced technologies are relatively modest in this case. In addition, the growth in miscellaneous electronic appliances, which is the fastest growing component of electricity demand, is assumed to grow at the same rate projected in the reference case. Because there are no data to characterize their efficiency levels, growth rates are based on the potential for more households to use these appliances. Consumer hurdle rates, which are important determinants of the projected penetration of more efficient appliances, are also assumed to remain at the same levels as in the reference case.

The advanced technology assumptions are based on increased research and development funding that could lead to improvements in available technologies but would not impact the way in which consumers make decisions to purchase new equipment. Average delivered electricity prices are projected to be lower by 8 percent in 2020 relative to the reference case, reducing the financial incentive to invest in energy efficiency. These factors all contribute to the modest savings in residential energy demand projected in this case.

As a result of the lower projected energy consumption, residential sector CO_2 emissions are projected to be reduced by 12 and 26 million metric tons carbon equivalent, or 3 and 7 percent, in 2010 and 2020, respectively. More than half of the CO_2 reduction in 2010 results from lower projected electricity demand, while 65 percent of the CO_2 reduction in 2020 is attributable to lower electricity demand.

Commercial

In the advanced technology case, projected commercial electricity demand is 1 percent lower in 2010 and 2 percent lower in 2020, relative to the reference case, as consumers adopt more advanced lighting technologies and information technology-related equipment. Lower natural gas prices lead to higher projected natural gas consumption, offsetting part of the reduction in delivered electricity use. The availability of advanced technologies does not necessarily lead to their adoption. Factors other than energy costs, such as limited investment funds and different incentives for renters and owners still enter into purchase decisions. For this reason, consumer behavior in the advanced technology case is assumed to be the same as in the reference case. Therefore, with lower fuel prices, consumers are expected to have less incentive to invest in more efficient end-use equipment and distributed generation technologies, limiting the projected effect of more optimistic technology assumptions. The reference case represents the pace of technological progress expected with historical levels of research and development funding. Technological progress in the advanced technology case represents the potential impacts of increased research and development. However, the amount of funding required to achieve these advances is unknown.

Due to the reduced electricity demand, projected commercial sector CO_2 emissions are 6 million metric tons carbon equivalent, or 2 percent, lower than reference case projections in 2010 and 16 million metric tons carbon equivalent, or 5 percent, lower in 2020, including CO_2 emissions from the fuels used to generate electricity for the commercial sector.

Industrial

In the advanced technology case, 0.9 quadrillion Btu less energy is projected to be consumed by the industrial sector in 2020 than in the reference case. Industrial delivered energy intensity is projected to decline by 1.6 percent per year though 2020 in this case, compared with a 1.5-percent annual decline in the reference case. While some individual industry intensities are projected to decline almost twice as rapidly in the advanced technology case as in the reference case, the aggregate intensity is not as strongly affected because the composition of industrial output is similar in the two cases.

In the advanced technology case, projected consumption of all industrial energy sources is lower compared to the reference case, except for renewables. Consumption of renewable energy sources is projected to be higher by 7 percent, or 0.2 quadrillion Btu, in 2010 and by 16 percent, or 0.5 quadrillion Btu, in 2020. Most of the increase in renewables occurs in the paper industry. In the advanced technology case, more renewables are assumed to be available due to more efficient recovery of pulping liquor and wood byproducts. Due to the lower energy consumption, projected industrial CO_2 emissions are reduced by 18 and 42 million metric tons carbon equivalent, or 3 and 7 percent, in 2010 and 2020, respectively.

Transportation

For the transportation sector, the advanced technology case includes assumptions of lower costs and improved efficiencies for advanced technologies, comparable to those provided by the DOE Office of Transportation Technologies, the American Council for an Energy-Efficient Economy, and Argonne National Laboratory for light and heavy vehicles and to those assumed in a DOE interlaboratory study for air, rail, and marine travel.[29] The efficiency gains rely heavily on the success of government research and development programs as well as a shift in consumer demand for more efficient technologies.

In the advanced technology case, new light-duty vehicle fuel efficiency is projected to improve to 31.9 miles per gallon by 2010 and to 34.9 miles per gallon by 2020, compared to 27.2 and 28.1 miles per gallon in 2010 and 2020, respectively, in the reference case. Heavy truck, aircraft, rail, and marine efficiencies are all projected to improve. Compared to the reference case, there is no significant change in travel demand projected for any travel mode with the exception of rail and natural gas pipelines which are reduced due to projected reductions in coal and natural gas consumption relative to the reference case. As a result of the projected efficiency improvements, transportation energy use is projected to be reduced by 4 percent in 2010 and by 10 percent in 2020, compared to the reference case, and projected CO_2 emissions are reduced by 29 and 77 million metric tons carbon equivalent, or 5 and 11 percent, in 2010 and 2020, respectively.

Electricity and Renewables

In the advanced technology case, improvements in the projected efficiency of end-use equipment and building shells as well as in the cost and performance of electricity generating technologies are assumed to be available earlier than in the reference case. These technological improvements reduce the projected growth in electricity sales as consumers benefit from more efficient end-use equipment than in the reference case. Electricity sales are expected to grow at an average annual rate of 1.6 percent compared with 1.8 percent in the reference case. As a result, the need for new investment in generation capacity and other equipment is reduced. The lower level of investment, combined with lower projected costs of fuels used to generate electricity, results in lower projected electricity prices. For example, prices to residential customers in 2020 are projected to be 8 percent lower than in the reference case.

Average delivered electricity prices to all consumers in the advanced technology case are projected to be 10 percent lower than in the reference case in 2020. In addition, CO_2 emissions are reduced due to reductions in the use of fossil fuels to generate electricity. In 2020, projected CO_2 emissions from electricity generators are 57 million metric tons carbon equivalent lower than the 773 million metric tons carbon equivalent in the reference case. There are also modest reductions in projected emissions of NO_x and Hg.

In the advanced technology case, emissions are reduced primarily because the lower projected demand for electricity reduces the use of coal and natural gas for electricity generation relative to the reference case. Coal consumption by electricity generators is expected to be lower by 57 million short tons in 2020 while projected natural gas use is lower by 2 trillion cubic feet, even though the projected delivered prices of these fuels to generators are considerably lower than in the reference case. Lower projected consumption of fossil fuels reflects the lower requirements for generation.

By 2020, the need for new capacity is expected to be 33 gigawatts lower, compared to the cumulative capacity additions in the reference case, which are mostly natural-gas-fired combined-cycle plants. However, more coal and renewable capacity additions are expected because of the assumed cost and performance improvements in the advanced technology case. Almost 7 gigawatts more coal capacity is expected to be constructed by 2020 compared with the reference case. The projected increase in renewable capacity is more modest, an additional 2 gigawatts of cumulative capacity additions by 2020 in the advanced technology case, compared to the reference case. Although no new nuclear plants are expected to be constructed, there are fewer retirements of existing plants because the advanced technology case assumes lower aging-related costs. By 2020, 10 gigawatts of nuclear capacity is projected to be retired, compared to 21 gigawatts in the reference case. As a result, projected nuclear generation in 2020 is 10 percent higher than in the reference case.

Natural Gas

In the advanced technology case, more rapid technological change in the end-use and generating sectors results in increased efficiency, which reduces the demand for natural gas compared to the reference case. Total natural gas consumption in the advanced technology case is projected to reach 32.4 trillion cubic feet in 2020, 7 percent lower than the 35.0 trillion cubic feet in the reference case. The largest decrease in consumption is in the electricity generation sector. By 2020, natural gas consumption by electricity generators, excluding cogenerators, is projected to reach 9.1 trillion cubic feet, 2.0 trillion cubic feet lower than it is in the reference case. Residential and industrial demand is also projected to be lower in the advanced technology case in 2020 by a total of 0.6 trillion cubic from the reference case.

[29]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond,* ORNL/CON-444 (Washington, DC, September 1997); Office of Energy Efficiency and Renewable Energy, Office of Transportation Technologies, *OTT Program Analysis Methodology: Quality Metrics 2000* (November 1998); J. DeCicco and M. Ross, *An Updated Assessment of the Near-Term Potential for Improving Automotive Fuel Economy* (Washington, DC: American Council for an Energy-Efficient Economy, November 1993); and F. Stodolsky, A. Vyas, and R. Cuenca, *Heavy and Medium Duty Truck Fuel Economy and Market Penetration Analysis, Draft Report* (Chicago, IL: Argonne National Laboratory, August 1999).

The *AEO2001* reference case assumes that technological improvements will lower drilling costs, increase success rates, and increase reserves added per well at the average rates of change measured over the last two decades. In the advanced technology case, the improvement in the projected rate of technological development for natural gas exploration and development is assumed to be faster, and it influences domestic natural gas supplies in three ways. First, faster technological development lowers the costs of future drilling. Second, the ratio of successful wells to total wells drilled is higher, as technological improvement reduces the number of dry holes. Finally, the volume of reserves added with each well drilled is higher, allowing fewer wells to be drilled to meet required production volumes.

As in the high oil and natural gas technology case in *AEO2001*, the rates of technological change for onshore, conventional gas sources, the largest component of domestic production, are assumed to be 25 percent faster in the advanced technology case than in the reference case. With these assumptions, onshore, conventional natural gas reserves per well drilled are larger and drilling is more accurate and less expensive, allowing more production with lower cost than in the reference case. The technology growth rates assumed in the advanced technology case have been seen over short periods in the last two decades but are higher than the average achieved over the same time period. For unconventional and offshore production, faster technology improvements lead to earlier development of these resources than assumed in the reference case, allowing for earlier production.

While the more rapid technological improvement allows natural gas supplies to grow more quickly, the advanced technology case also reduces the total demand for natural gas even though prices are lower. In the advanced technology case, lower demand and more easily accessible supplies result in lower wellhead prices which are projected to be $2.20 per thousand cubic feet in 2020, compared to $3.10 per thousand cubic feet in the reference case, relative to an estimated level of $3.53 per thousand cubic feet in 2000, converted to 1999 dollars.

The assumptions used in the high oil and natural gas technology case in *AEO2001* are designed to analyze the effects of rapid technological growth. The advanced technology case in this study shows that these rapid technological change assumptions can have a strong impact on natural gas prices and potential supply. However, the actual mechanism of reaching these higher levels of technological growth, such as additional expenditures for research and development, is not explicitly represented in this case. In order to increase the rate of technological development to the level projected in the advanced technology case, research and development expenditures would likely need to be higher than they have been in recent years. Given the lower prices in the advanced technology case, the effort required to increase the rate of technological improvement to the levels achieved in the *AEO2001* rapid technology case may be difficult to sustain. The advanced technology case evaluates what the effects of faster technological growth could be on natural gas markets but does not determine how these advances might be achieved nor does it assess the likelihood that faster technological progress will actually occur. Maintaining the high rate of technological development assumed in this case could prove challenging for the industry.

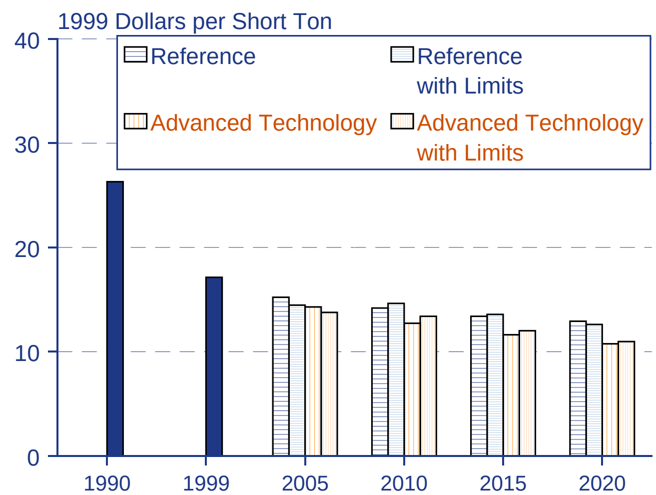
Coal

In the advanced technology case, projected coal prices to all sectors decline relative to the reference case, as a result of assumed higher labor productivity gains in the coal industry of 3.8 percent per year and decreasing factor input costs of 0.5 percent per year (Figure 20). Technology improvements also occur for natural gas supply and electricity generation technologies, and a variety of efficiency gains are achieved in the end-use demand sectors, offsetting the positive impact that lower fuel prices would otherwise have on projected coal consumption. Because electricity sales are projected to increase at a lower rate between 1999 and 2020 compared to the reference case, projected coal shipments to electricity generators, excluding cogenerators, are 5 percent lower in 2020 than in the reference case. In 2020, coal is projected to have a 48-percent market share of generation, excluding cogenerators, reduced from 54 percent in 1999, but approximately the same share as in the reference case.

Impact of Emissions Limits on the Advanced Technology Case

In 2020, the average delivered price of electricity is projected to be 22 percent higher in the advanced technology case with emissions limits than in the same case without the limits. Projected wellhead natural gas prices are also higher by 18 percent as a result of higher natural gas consumption by electricity generators. Due to

Figure 20. Coal Minemouth Prices in Four Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

the higher energy prices, total energy consumption is projected to be reduced by 5 quadrillion Btu in 2020, or 4 percent, relative to the advanced technology case without emissions limits, and energy expenditures are higher.

The primary energy intensity of the economy is projected to decline at an average annual rate of 2.1 percent between 1999 and 2020 in the advanced technology case with emissions limits, compared to 1.9 percent in the advanced technology case without limits. Total projected consumption of coal and electricity is lower compared to the advanced technology case without limits; however, the projected consumption of natural gas, nuclear power, and renewable sources is higher as electricity generators shift from using coal to using more existing nuclear power and more natural gas and renewable generating technologies. Because of reduced energy consumption and the shift in the fuel mix to more natural gas, renewables, and nuclear power, projected CO_2 emissions in 2020 are reduced by 231 million metric tons carbon equivalent, or 12 percent, relative to the advanced technology case without limits.

Electricity and Renewables

When emissions limits are included in the advanced technology case, there are additional costs of producing electricity that are reflected in the prices that consumers pay. Reducing emissions of SO_2, NO_x, Hg, and CO_2 results in 22-percent higher projected average delivered electricity prices in 2020, compared to the case without emissions limits. Consumers respond to the higher projected electricity prices by reducing projected consumption by 7 percent in 2020, compared to the advanced technology case without limits. The increase in projected electricity prices results in part from increased projected costs of fossil fuels used to generate electricity and the costs of holding or buying emissions permits. Effective delivered natural gas prices to generators in 2020 are projected to be 56 percent higher than in the case without emissions limits, while effective coal prices are 166 percent higher, due to the costs of obtaining CO_2 emissions permits and, for natural gas, the higher costs of production.

SO_2, NO_x, CO_2, and Hg emissions reductions are partly achieved by changes in the projected mix of capacity used to generate electricity. In the advanced technology case with emissions limits, additional construction of 35 gigawatts of natural-gas-fired combined-cycle and combustion turbine capacity and almost 18 gigawatts of renewables capacity is projected compared to the case without emissions limits. Natural gas use by electricity generators (excluding cogenerators) is expected to be 2.8 trillion cubic feet higher in 2020, or 30 percent, compared to the case without emissions limits. The additional projected renewable capacity is mostly wind and geothermal, plus increased output from biomass co-fired with coal in coal-fired plants, along with small increases in municipal solid waste and dedicated biomass. In addition, fewer existing nuclear plants are expected to be retired, 3 gigawatts compared to 10 gigawatts in the case without emissions limits, raising projected nuclear power generation by 7 percent in 2020.

In addition to purchasing allowance permits, electricity generators are also expected to make investments in emission control equipment to reduce emissions of SO_2, NO_x, and Hg. In the advanced technology case with emissions limits, there are 31 gigawatts more SO_2 scrubber retrofits added when emission limits are imposed, compared to 10 gigawatts in the advanced technology case without emissions limits. In both the advanced technology cases with and without emission limits, there are investments in selective catalytic reduction and selective noncatalytic reduction to reduce NO_x emissions. However, the level is somewhat higher in the case with emission limits reflecting the more stringent reductions required for NO_x emissions. Control equipment, including fabric filters and spray coolers, is also projected to be built to reduce Hg emissions in the case with emissions limits. The level of investment in Hg controls is greater in the advanced technology case with emissions limits than in the reference case with emissions limits because the higher levels of coal-fired generation require more controls to achieve the emission limits.

The projected allowance price for SO_2 increases from $145 per ton in the advanced technology case to $703 per ton in the same case with emissions limits. After the Hg limits are reached, the cost of additional scrubbers is reflected in the SO_2 allowance price. Similar to the reference case with the emissions limits, the cost for NO_x emission allowances is expected to decline to zero because the actions taken to meet the CO_2 limits result in NO_x emissions being within the specified limit. In 2020, the cost of the CO_2 emission allowances is expected to be $58 per metric ton carbon equivalent which is less than one-half the cost of those allowance costs in the reference case with emissions limits. The CO_2 allowance price declines from 2015 to 2020 because of the increasing share of natural gas. The cost of Hg allowances in the advanced technology case with emissions limits is expected to reach $374 million per ton compared to $306 million per ton in the reference case without emissions limits. Because there are fewer changes to meet the CO_2 emissions levels in the advanced technology case, which also help to reduce Hg emissions, more effort is needed to meet the Hg limits.

The lower projected electricity demand and the improved generator efficiency in the advanced technology case reduce the cost to electricity generators of achieving compliance with the CO_2 emissions limits. In the advanced technology case with emissions limits, the cumulative resource costs are expected to be $1,979 billion, compared to $1,837 billion in the advanced technology case without the limits, an 8-percent increase. This additional $142 billion cost of complying with the emissions limits in the advanced technology case is $35 billion less than the cost of complying with the same limits under reference case assumptions.

When the emissions limits are imposed on the advanced technology case, the incremental annualized resource costs for electricity generators in 2007 are projected to be $19.4 billion, declining to $16.8 billion and $11.9 billion in 2010 and 2020, respectively—smaller incremental costs due to the emissions limits than are projected in the reference case with emissions limits.

Natural Gas

Similar to the reference case, imposing emissions limits in the advanced technology case results in higher demand and higher prices for natural gas, compared to the same case without the limits. However, the more rapid growth in natural gas exploration and production technology in the advanced technology case restrains projected natural gas prices from rising as high as in the reference case with emissions limits. In 2020, the average wellhead price of natural gas is projected to be $2.60 per thousand cubic feet in the advanced technology case with emissions limits. This is 18 percent higher than the $2.20 per thousand cubic feet in the same case without emissions limits, but 30 percent lower than the $3.72 per thousand cubic feet reached by imposing the emissions limits on the reference case.

Natural gas consumption by electricity generators, excluding cogenerators, is projected to reach 11.9 trillion cubic feet in 2020 in the advanced technology case with emissions limits, an increase of 2.8 trillion cubic feet, or 30 percent, from the same case without emissions limits. Natural gas consumption is also projected to be higher in the commercial and industrial sectors, primarily for cogeneration. Total natural gas consumption is projected to reach 35.6 trillion cubic feet by 2020 in the advanced technology case with emissions limits, 3.3 trillion cubic feet higher than in the case without emissions limits.

Higher natural gas demand caused by the imposition of the emissions limits results in more domestic production and higher prices. Higher domestic natural gas production accounts for nearly all of the difference in the natural gas supplies. In 2020, projected domestic natural gas production in the advanced technology case with emissions limits is 30.1 trillion cubic feet, 2.8 trillion cubic feet higher than projected in the case without emissions limits. Unlike in the reference case, the additional demand for natural gas does not lead to a strong increase in natural gas imports. Although total natural gas demand increases through 2020, the average wellhead price is projected to decline slowly after peaking at $3.03 per thousand cubic feet in 2007 due to the impact of the advanced technology assumptions. These lower projected prices do not make the additional imports which are projected to occur in the reference case with emissions limits feasible. Therefore, most of the supply response to the higher levels of natural gas consumption in the advanced technology case with emissions limits is projected to come from increased natural gas production both onshore and offshore in the lower 48 States.

Coal

The addition of emissions limits to the advanced technology case is projected to result in significant shifts in coal consumption levels and supply patterns. In 2020, projected consumption by electricity generators is reduced to 563 million short tons, compared to 1,133 million short tons in the advanced technology case without emissions limits, a 50-percent difference. Projected coal production patterns shift rapidly in response to the stringent limits. Lignite production in 2010 is projected to decline from 92 million short tons to 12 million short tons with the addition of the limits because of its high Hg content. Projected coal production from the Powder River Basin also declines by 288 million short tons by 2020 because the CO_2 limits and the resulting CO_2 allowance costs result in displacement of coal by natural gas in many electricity generation markets.

Rocky Mountain coal, which has low Hg and SO_2 content, initially gains in output, primarily replacing lignite, and generally maintains production levels similar to the advanced technology case without limits. In 2020, projected bituminous coal production is 175 million short tons lower in the advanced technology case with limits, compared to the same case without limits, but increases market share relative to subbituminous coal, serving the electricity generation market at sharply reduced levels. Although low-sulfur coal is projected to decline at the slowest rate, gradual withdrawals from the SO_2 allowance bank and the installation of scrubbers in existing coal plants help to maintain a reduced level of production from mid- and high sulfur coal sources. The industrial and export markets are assumed to be largely unaffected by the emission limits.

End-Use Demand

Residential

The impact of emissions limits on the advanced technology case is very similar to the impact on the reference case. Given the lower projected demand in the advanced technology case, relative to the reference case, emissions limits are easier to attain, causing energy prices to increase less than in the reference case with emissions limits. As a result of the emissions limits applied to the advanced technology case, residential electricity prices are 20 percent higher in 2010, compared to 25 percent in the reference case with emissions limits, causing a 6-percent reduction in projected electricity demand in the advanced technology case with emissions limits compared to the same case without limits. In 2020, the residential electricity prices are 16 percent higher in the advanced technology case when the emissions limits are imposed, reducing the projected electricity demand by 5 percent. The impact of the emissions limits on residential natural gas prices and consumption is very similar to the reference case. CO_2 emissions are reduced by 69 and 83 million metric tons carbon equivalent, or 21 and 23 percent, in 2010 and 2020, respectively, compared to the advanced technology case without emissions limits, primarily due to the lower demand for electricity.

Commercial

Imposing emissions limits on the advanced technology case reduces projected commercial delivered energy consumption by 3 percent in 2010 and by 2 percent in 2020, relative to the case without emissions limits, while projected electricity demand is reduced by 5 and 6 percent in 2010 and 2020, respectively. Projected electricity and natural gas prices in 2010 are 28 percent and 10 percent higher, respectively, with emissions limits compared to the case without limits. In 2020, the electricity and natural gas prices are projected to be 22 and 9 percent higher.

As in the reference case with emissions limits, the higher projected electricity prices in the advanced case with emissions limits encourage commercial establishments to turn to cogeneration, using natural gas to produce 79 percent and 339 percent more electricity in 2010 and 2020 than projected in the advanced case without emissions limits. Projected CO_2 emissions in the commercial sector are lower by 68 and 81 million metric tons carbon equivalent, or 22 and 24 percent, in 2010 and 2020, respectively, due to the emissions limits.

Industrial

When the emissions limits are applied to the advanced technology case, total delivered energy consumption in the industrial sector is projected to be essentially unchanged from the advanced technology case without the emissions limits. Applying emissions limits in the advanced technology case is projected to raise the industrial electricity price by 34 and 29 percent in 2010 and 2020, respectively, while the projected natural gas price is 17 and 15 percent higher. As a result, the consumption of purchased electricity is projected to be 6 percent lower in 2010 and 11 percent lower in 2020 relative to the advanced technology case without emissions limits.

In the advanced technology case with emissions limits, projected industrial natural gas consumption is 0.4 quadrillion Btu higher in 2020 than in the advanced technology case without emissions limits, accounting for the slight increase in total industrial energy consumption. Cogeneration using natural gas is projected to be 57 percent higher in 2010 than in the case without the emissions limits and 100 percent higher in 2020. Projected CO_2 emissions are reduced by 53 and 65 million metric tons carbon equivalent, or 10 and 12 percent, in 2010 and 2020, primarily due to the lower purchased electricity demand.

Transportation

Emissions limits have a similar impact on the transportation sector in the advanced technology case as in the reference case. The only significant change with the emissions limits is a projected shift of travel from rail to pipeline due to a shift in fuel utilization from coal to natural gas by electricity generators. Total projected energy consumption in the transportation sector is slightly higher due to higher pipeline use of natural gas, and CO_2 emissions are projected to be essentially unchanged.

Macroeconomic Impacts

Methodology

The imposition of emission limits on electricity generators is expected to affect the U.S. economy primarily through higher delivered energy prices. Higher energy costs would reduce the use of energy by shifting production toward less energy-intensive sectors, by replacing energy with labor and capital in specific production processes, and by encouraging energy conservation. Although reflecting a more efficient use of higher cost energy, the change would also tend to lower the productivity of other factors in the production process because of a shift in the prices of capital and labor relative to energy. Moreover, an increase in energy prices would raise non-energy intermediate and final product prices and introduce cyclical behavior in the economy, resulting in output and employment losses in the short term. In the long term, however, the economy can be expected to recover and move back to a more stable growth path.

Relative to a reference case projection for energy markets, a case with emissions limits has impacts on the aggregate economy. However, with alternative projections for energy markets, the same emissions limits will have different impacts on energy markets and subsequently different impacts on the economy. The macroeconomic assessment in this section evaluates the impacts of emissions limits on the reference case and the advanced technology case.

The macroeconomic analysis assumes a marketable emissions permit system, with a no-cost allocation of permits. In meeting the targets, power suppliers are free to buy and sell allowances at a market-determined price for the permits, which represents the marginal cost of abatement of any given emission.

Macroeconomic Impacts of Emissions Limits on the Reference Case

The introduction of emissions limits in the reference case results in a substantial increase in energy prices and subsequently in aggregate prices for the economy. The wholesale price index for fuel and power (WPI-Fuel and Power) gives an indication of the overall change in energy prices across all fuels. The WPI-Fuel and Power is projected to rise rapidly above the reference case without emissions limits by 14.6 percent in 2007, the target year for emissions reduction (Table 13). Thereafter, this index remains approximately 15 percent above the reference case without limits through 2020.

Higher projected electricity and natural gas prices initially affect only the energy portion of the consumer price index (CPI). The higher projected energy prices are expected to be accompanied by general price effects as they are incorporated in the prices of other goods and services. In this case, the level of the CPI is projected to be about 0.7 percent above the reference case without limits by 2007 and to moderate only slightly to approximately 0.6 percent above the reference case level through 2020.

How would the projected changes in energy prices affect the general economy? Capital, labor, and production processes in the economy would need to adjust to accommodate the new, higher set of energy and non-energy prices. Higher energy prices would affect both consumers and businesses. Households would face higher prices for energy and the need to adjust spending patterns. Rising expenditures for energy would take a larger share of the family budget for consumption of goods and services, leaving less for savings. Energy services also represent a key input in the production of goods and services. As energy prices increase, the costs of production rise, placing upward pressure on the prices of all intermediate goods and final goods and services in the economy. These transition effects tend to dominate in the short run, but dissipate over time.

The unemployment rate is projected to rise by 0.4 percentage points above the reference case with no limits in 2007. Along with the projected increase in inflation and unemployment, real output of the economy is projected to be lower. Real GDP is projected to be 0.8 percent lower relative to the reference case with no limits in 2007, and employment in non-agricultural establishments is projected to be lower by one million jobs. Similarly, real disposable income is expected to be reduced by 1.0 percent.

As the economy adjusts to higher energy prices, projected inflation begins to subside after 2007. At the same time, the economy begins to return to its long-run growth path. By 2020, the projected unemployment rate is 0.1 percentage points above the reference case, and real GDP is projected to be 0.3 percent below the reference case projection. The impact on non-agricultural employment is projected to moderate to just over 400,000 jobs relative to the reference case in 2020.

Table 13. Macroeconomic Impacts of Emissions Limits in the Reference and Advanced Technology Cases, 2007, 2010, and 2020

Projections	2007	2010	2020
Wholesale Price for Fuel and Power (Percent Change From Case Without Limits)			
Reference Case	14.6	15.0	14.7
Advanced Technology	13.6	13.4	10.5
Real Gross Domestic Product (Percent Change From Case Without Limits)			
Reference Case	-0.8	-0.3	-0.3
Advanced Technology	-0.7	-0.2	-0.1
Consumer Price Index (Percent Change From Case Without Limits)			
Reference Case	0.7	0.7	0.6
Advanced Technology	0.6	0.4	0.1
Unemployment Rate (Change From Case Without Limits)			
Reference Case	0.4	0.1	0.1
Advanced Technology	0.3	0.1	0.0
Disposable Income (Percent Change From Case Without Limits)			
Reference Case	-1.0	-0.7	-0.5
Advanced Technology	-0.9	-0.4	-0.2
Nonagricultural Employment (Million Jobs, Change From Case Without Limits)			
Reference Case	-1.0	-0.4	-0.4
Advanced Technology	-0.8	-0.3	-0.2

Note: All percent changes have been rounded to one decimal point.
Source: Simulations of the DRI Macroeconomic Model of the U.S. Economy based on National Energy Modeling System, runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and SCENBEM.D081701A.

Macroeconomic Impacts of Emissions Limits on the Advanced Technology Case

The advanced technology case incorporates more rapid improvements for end-use demand, electricity generation, and fossil fuel supply technologies, relative to the reference case. As a result, the impact of emissions limits on energy prices is moderated in the advanced technology case, compared to the reference case. Imposing emissions limits raises the WPI-Fuel and Power by 13.6 percent, relative to the advanced technology case without the limits, compared to the 14.6-percent increase in the reference case. By 2020, the WPI-Fuel and Power is projected to be 10.5 percent higher in the advanced technology case when emissions limits are imposed, compared to 14.7 percent higher in the reference case when the limits are imposed.

Because the impact on energy prices is less in the advanced technology case than in the reference case, the impacts on price, employment, and real output in the aggregate economy are also less. The peak impact on the CPI in 2007 is projected to be 0.6 percent as compared to 0.7 percent in the reference case. By 2020, in the advanced technology case with emissions limits, the projected CPI is only 0.1 percent above the same case without the limits, and the impact on real GDP is projected to be only 0.1 percent below the advanced technology case without the limits. Compared to the reference case, imposing emissions limits under the advanced

Macroeconomic Effects of Alternative Implementation Instruments

All the cases considered assume a marketable emission permit system, with a no-cost allocation of the permits based on historical emissions. In meeting the targets, power suppliers are free to buy and sell allowances at a market-determined price for the permits, which represents the marginal cost of abatement of any given emission. An alternative form of permit system would auction the permits to power suppliers. The price paid for the auctioned permits would equal the price paid for traded permits under the no-cost allocation system used for this study. However, the two systems imply a different distribution of income.

In the no-cost allocation system, there would be a redistribution of income flows between power suppliers in the form of purchases of emission permits. There would be no net burden on the power suppliers as a whole, only a transfer of funds among firms. While all firms are expected to benefit from trading, the burden would vary among firms. With a Federal auction system, in contrast, there would be a net transfer of income from power suppliers to the Federal government. The key question at this juncture turns on the use of the funds by the Federal government. If the funds were returned to the power suppliers, the effect would be the same as in the no-cost allocation scheme, but with the Federal government establishing the permit market mechanism. Another use of the funds might be to return them to consumers either in the form of a lump-sum transfer or in the form of a personal income tax cut, compensating consumers for the higher prices paid for energy and non-energy goods and services.[a]

Relative to the no-cost allocation of permits, an auction that transfers funds to consumers in a lump sum would help to maintain their level of overall consumption. With the transfer, however, total investment would decline relative to the allocation system. The two effects would tend to counterbalance each other, but not completely. Returning collected auction funds to the consumer would tend to have a slightly more positive effect than the negative effect on investment for the first few years, but investment would tend to rebound faster and contribute increasingly to the recovery. As a result, real GDP would be expected to recover to reference case levels faster under the no-cost allocation system. Over the entire period, however, the net impacts on real GDP are expected to be similar in both magnitude and pattern under the two potential allocation schemes.

Another approach is to recycle the auctioned revenues to either consumers or businesses through a reduction in marginal tax rates on capital or labor. Unlike the no-cost allocation or the lump-sum payment to consumers, this approach may lower the aggregate cost to the economy by shifting the tax burden away from distortionary taxes on labor and capital toward the taxation of an environmental pollutant. Most often research on this topic is based on a general equilibrium approach, where all factors are assumed to be utilized fully, as in the work by Goulder, Parry, and Burtraw.[b] Revenue recycling benefits may also apply in a setting where transition effects on the economy, such as considered in the current EIA study, are the focus.[c]

[a]For a discussion of the relative merits of alternative instruments, see Perman, Ma, and McGilvray, “Pollution Control Policy,” in *Natural Resource and Environmental Economics* (Addison Wesley Longman, 1996).

[b]L.H. Goulder, I.W.H Parry, and D. Burtraw, “Revenue-Raising Versus Other Approaches to Environmental Protection: The Critical Significance of Pre-existing Tax Distortions,” *RAND Journal of Economics,* Vol. 28. (Winter 1997), pp. 708-731.

[c]See also Energy Information Administration (EIA), *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*, SR/OIAF/98-03 (Washington, DC, October 1998), Chapter 6, “Assessment of Economic Impacts” and EIA, *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard*, SR/OIAF/2001-03 (Washington, DC, July 2001), Chapter 4, “Fuel Market and Macroeconomic Impacts.”

technology assumptions is less costly to the aggregate economy as it transitions to a new equilibrium position toward the end of the forecast period. In the advanced technology case, there is a lower projected demand for energy and lower emissions, due to the introduction of more advanced and more efficient technologies at a lower cost. Thus, the structure of the baseline energy market has a significant effect on the magnitude and profile of the economic impacts of emissions limits.

3. Analysis of Strategies with Policies from *Scenarios for a Clean Energy Future*

In addition to the reference case and advanced technology case, which were analyzed in Chapter 2, the letter of request from Senators Jeffords and Lieberman asked the Energy Information Administration (EIA) to analyze the impacts of emissions limits on electricity generators in two cases incorporating the policies from the interlaboratory study *Scenarios for a Clean Energy Future* (*CEF*).[30] As discussed in Chapter 1, *CEF* proposed two sets of policies in moderate and advanced cases to reduce energy consumption and carbon dioxide (CO_2) emissions. The *CEF* analysis was conducted using a revised version of EIA's National Energy Modeling System (NEMS) used for the *Annual Energy Outlook 1999* (*AEO99*), referred to as *CEF*-NEMS.

For this analysis, the *CEF* assumptions were implemented as described in this chapter in the version of NEMS used for the *Annual Energy Outlook 2001* (*AEO2001*), published in December 2000.[31] The cases that implement the *CEF* policies are denoted as the *CEF-JL* (*Clean Energy Futures* – Jeffords / Lieberman) moderate and advanced cases. Chapter 1 describes the most significant changes in the model methodologies and assumptions between the *AEO99* and *AEO2001* versions of NEMS, the revisions to the *AEO99* version of NEMS in *CEF*, and the revisions included in the reference case of this analysis from the *AEO2001* version of NEMS.

This chapter describes the various *CEF* policies in the moderate and advanced cases and their implementation in both the *CEF* analysis and this analysis on a sector-by-sector basis and discusses the feasibility of the impacts of the policies in *CEF*. The impact of the *CEF* policies in the *CEF-JL* cases, which incorporate the *CEF* policies in the current version of NEMS, compared to the reference case is then discussed, followed by the impact of the emissions limits on the *CEF-JL* cases. The same emissions limits on electricity generators (excluding cogenerators) are applied to the *CEF-JL* cases as to the reference and advanced technology cases in Chapter 2.[32] The start date for emissions reductions is 2002. By 2007, nitrogen oxides (NO_x) emissions are reduced to 75 percent below 1997 levels, sulfur dioxide (SO_2) emissions to 75 percent below the full implementation of the Phase II requirements under Title IV of the Clean Air Act Amendments of 1990 (CAAA90), mercury (Hg) emissions to 90 percent below 1999 levels, and CO_2 emissions to 1990 levels.

The authors of the *CEF* report proposed a number of policies for the end-use demand and electricity generation sectors, including increased research and development funding, equipment standards, financial incentives, voluntary programs, and other regulatory initiatives. The purpose of these policies was to promote the development and adoption of more efficient technologies, reduce energy service demand, and encourage the use of cleaner, less carbon-intensive fuels. One system-wide policy is the imposition of a domestic CO_2 trading system with an assumed permit price of $50 per metric ton carbon equivalent, which would be announced in 2002, implemented in 2005, and applied to all energy sectors and all fuels. This policy is assumed in the *CEF-JL* advanced cases only, both with and without the emissions limits on electricity generators. In the moderate *CEF-JL* case with emissions limits, the only emissions costs are those imposed on electricity generators as a result of the emissions limits.

In the request for this analysis, EIA was asked to assume the *CEF* scenarios in order to analyze the impacts of the emissions limits on projections with lower energy demand. In accordance with this request, the impacts of the policies from *CEF* are implemented for this analysis. These impacts are due to assumed changes in consumer behavior that are not consistent with historical behavior patterns, result from research and development funding increases that have not occurred and for which there is no analytical basis for the impacts of the funding on technological improvements, and voluntary or information programs for which there is also no analytical basis for the impacts.

The results of the *CEF-JL* cases should not be interpreted as an EIA analysis of the *CEF* policies, because, as noted

[30]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL / CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), web site www.ornl.gov / ORNL / Energy_Eff / CEFOnep.pdf.

[31]Energy Information Administration, *Annual Energy Outlook 2001*, DOE / EIA-0383(2001)(Washington, DC, December 2000), web site www.eia.doe.gov / oiaf / aeo / index.html.

[32]At this time, emissions limits on cogenerators are not represented.

later in this chapter, EIA does not necessarily agree with the assumptions and projected levels of impacts in the *CEF* analysis. In addition, many of the *CEF* policies are dependent on increases in research and development funding or require investments in more efficient or less carbon-intensive equipment by the public and private sectors. The total cost of achieving these policies is not quantified in this analysis but is likely to be significant, and although the environmental benefits of the advanced case would be higher than those of the moderate case, the associated costs would be higher as well.

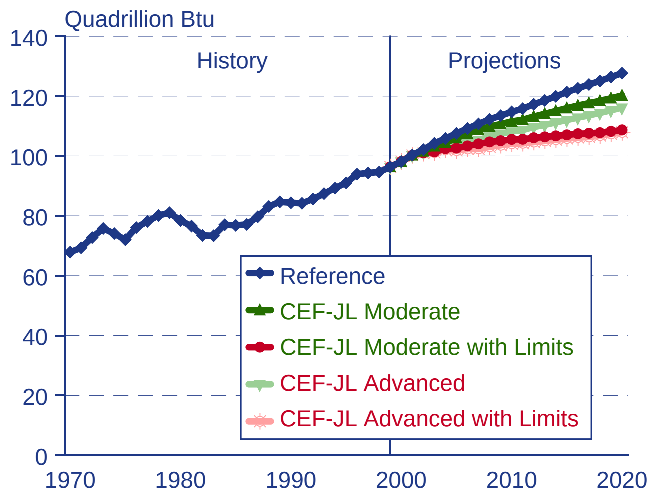
Summary of Impacts of *CEF* Policies and Emissions Limits in the *CEF-JL* Cases

Overall, primary energy consumption in 2020 is projected to be reduced from 128 quadrillion British thermal units (Btu) in the reference case without emissions limits to 120 quadrillion Btu and 109 quadrillion Btu in the *CEF-JL* moderate and advanced cases without emissions limits, reducing consumption by 6 and 15 percent, respectively (Figure 21 and Table 14). The projected annual average decline in primary energy intensity—defined as total energy consumption per dollar of gross domestic product (GDP)—between 1999 and 2020 is 1.9 and 2.4 percent in the *CEF-JL* moderate and advanced cases, respectively, compared to 1.6 percent in the reference case (Figure 22). In the residential and commercial sectors, a number of *CEF* policies were aimed at reducing the demand for electricity, which has the largest projected demand reduction in both sectors. In addition, in the advanced case, projected average delivered electricity prices in 2020 are higher than in the reference case, 6.6 cents per kilowatthour compared with 6.1 cents per kilowatthour hour, due to the $50 carbon fee. Purchased electricity demand is also projected to be lower in the industrial sector in both cases, relative to the reference case, particularly in the *CEF-JL* advanced case which assumes more available renewables and the $50 carbon fee. Total projected electricity consumption in 2020 is reduced by 12 percent and 19 percent in the *CEF-JL* moderate and advanced cases, respectively, relative to the reference case.

In the electricity generation sector, coal-fired generation in 2020 is projected to be very similar in the *CEF-JL* moderate case to the reference case. Projected natural-gas-fired generation is reduced by 39 percent in the *CEF-JL* moderate case compared to the reference case because the reduced projected demand for electricity reduces the requirements for new generation capacity which is largely natural-gas-fired. In 2020, renewable generation is projected to be higher by 4 percent in the *CEF-JL* moderate case, relative to the reference case. Although natural-gas-fired capacity additions and generation are lower in the *CEF-JL* moderate case than in the reference case, cumulative capacity additions of natural-gas-fired turbines and combined-cycle plants are projected to total 160 gigawatts by 2020, compared to 13 gigawatts of new renewable capacity, because natural-gas-fired plants remain more economical than renewable sources.

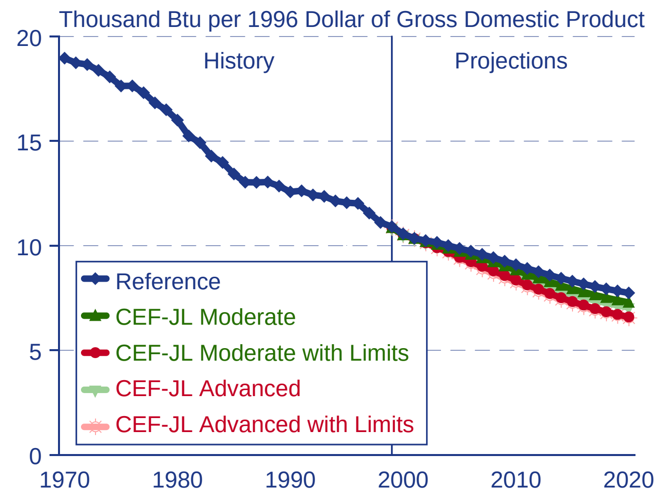
In the *CEF-JL* advanced case, projected coal-fired generation is reduced by 32 percent in 2020 relative to the reference case due to policies that encourage the use of natural gas and renewable generation, including the $50 carbon fee and a *CEF* policy to reduce particulate matter emissions by lowering the SO_2 emissions level mandated in CAAA90. In the advanced case, projected natural gas generation is lower than in the reference case but

Figure 21. Energy Consumption in Five Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS. D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 22. Primary Energy Intensity in Five Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS. D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Table 14. Energy Market Projections in the *CEF-JL* Moderate and Advanced Cases, 2020

Projections	1999	2020					
		Reference	*CEF-JL* Moderate		*CEF-JL* Advanced		
			Without Emissions Limits	With Emissions Limits	Without Emissions Limits	With Emissions Limits
Production (Quadrillion Btu)	**73.3**	**87.6**	**82.8**	**79.0**	**76.9**	**75.9**
Petroleum	15.1	15.2	14.3	14.8	14.2	14.5
Natural Gas	19.2	30.1	26.1	28.1	25.5	26.6
Coal	23.1	27.1	26.5	16.8	19.3	16.4
Nuclear Power	7.8	6.5	6.4	6.9	6.1	6.6
Renewable Energy	6.5	8.4	8.6	11.5	10.8	11.1
Primary Energy Consumption (Quadrillion Btu)	**96.3**	**127.7**	**120.2**	**116.2**	**108.7**	**107.9**
Petroleum	37.9	50.4	47.9	47.9	42.4	42.5
Natural Gas	22.3	35.9	31.3	33.8	30.7	32.0
Coal	21.4	26.3	25.8	15.7	18.3	15.5
Nuclear Power	7.8	6.5	6.4	6.9	6.1	6.6
Renewable Energy	6.5	8.4	8.6	11.5	10.8	11.1
Change in Primary Energy Intensity (Annual Percent Change, 1999-2020)	**—**	**-1.6**	**-1.9**	**-2.0**	**-2.4**	**-2.4**
Delivered Energy Consumption (Quadrillion Btu)	**72.1**	**97.3**	**92.1**	**91.6**	**84.7**	**84.6**
Residential	10.7	13.5	12.6	12.2	11.6	11.5
Commercial	7.6	10.9	10.0	9.8	9.7	9.6
Industrial	27.6	34.7	33.2	33.2	32.0	32.0
Transportation	26.3	38.2	36.3	36.3	31.5	31.5
Electricity Sales (Billion Kilowatthours)	**3,294**	**4,763**	**4,197**	**3,910**	**3,862**	**3,855**
Electricity Generation, Excluding Cogenerators (Billion Kilowatthours)	3,369	4,821	4,231	3,893	3,883	3,878
Coal	1,830	2,302	2,296	1,284	1,567	1,276
Petroleum	85	23	21	11	10	9
Natural Gas	370	1,488	908	1,330	1,181	1,416
Nuclear Power	730	610	595	646	575	617
Renewables	355	399	413	624	551	561
Electricity Generation by Cogenerators (Billion Kilowatthours)	303	440	443	607	470	463
Prices						
World Oil Price (1999 Dollars per Barrel)	17.22	22.41	22.41	22.41	22.41	22.41
Natural Gas Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	3.10	2.48	2.82	2.36	2.61
Coal Minemouth Price (1999 Dollars per Short Ton)	17.13	12.93	12.78	13.47	11.51	13.45
Average Delivered Electricity Price (1999 Cents per Kilowatthour)	6.7	6.1	6.0	7.2	6.6	6.6
Cumulative Resource Cost for Electricity Generation, 2001-2020 (Billion 1999 Dollars)	**—**	**2,031**	**1,751**	**1,913**	**1,682**	**1,811**
Emissions[a]						
CO_2 (Million Metric Tons Carbon Equivalent)[b]	1,511	2,044	1,914	1,690	1,615	1,558
SO_2 (Million Tons)	13.5	9.0	9.0	2.2	4.5	2.2
NO_x (Million Tons)	5.4	4.5	4.3	1.7	3.2	1.6
Hg (Tons)	43.4	45.2	46.2	4.3	29.4	4.3
Allowance Prices						
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	0	68	50	50
SO_2 (1999 Dollars per Ton)	0	200	184	905	707	670
NO_x (1999 Dollars per Ton)[c]	0	0	0	81	0	0
Hg (Million 1999 Dollars per Ton)	0	0	0	468	0	391

[a] CO_2 emissions are from all energy sectors. Other emissions are from electricity generators, excluding cogenerators.
[b] CO_2 emissions are from energy combustion only and do not include emissions from energy production or industrial processes.
[c] Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

has a similar market share in 2020. In 2020, renewable generation is projected to be higher by 38 percent in the *CEF-JL* advanced case, relative to the reference case, because the renewable portfolio standard (which requires a specified percentage of electricity sales to be generated from renewable sources other than hydropower), the extension of production tax credits for renewables, and the $50 carbon fee encourage the additional renewable generation. By 2020, cumulative capacity additions of renewable sources are projected to be 29 gigawatts higher than in the reference case.

In 2020, nuclear generation is projected to raise its share of the generation market, excluding cogeneration, from 13 percent in the reference case to 14 and 15 percent in the *CEF-JL* moderate and advanced cases, respectively, but nuclear generation is projected to be slightly lower across the cases due to the lower electricity demand. No new nuclear plants are constructed by 2020, and nuclear plant retirements are projected to be higher in the *CEF-JL* cases than in the reference case because lower projected natural gas prices in the *CEF-JL* cases improve the economics of new plant construction relative to the costs of continuing to operate existing nuclear plants.

Projected petroleum consumption in 2020 is lower by 5 and 16 percent in the moderate and advanced cases, respectively. Petroleum consumption is reduced largely due to *CEF* policies to reduce light-duty vehicle travel and improve the efficiency of all vehicles in the transportation sector, which is almost entirely dependent on petroleum. However, some reductions in petroleum demand are also projected to occur in the industrial sector due to boiler and process efficiency improvements and more rapid equipment retirement rates.

In 2020, total natural gas consumption is projected to be lower by 13 and 15 percent in the *CEF-JL* moderate and advanced cases, relative to the reference case, due to efficiency improvements in the end-use sectors that reduce the demand for natural gas and electricity, leading to further reductions in natural gas generation. Total projected coal consumption is also lower by 2 and 30 percent in the moderate and advanced cases due to reduced coal-fired generation. Renewable sources are the only energy sources for which projected consumption is higher in the *CEF-JL* cases than in the reference case, by 3 percent and 29 percent in the moderate and advanced cases, respectively, mainly due to more renewable generation but also due to higher use of renewables in the industrial sector in the advanced case.

Due to reduced demand, the production and price of both natural gas and coal are projected to be lower in the *CEF-JL* cases relative to the reference case. The lower prices are due to demand effects only, as there are no *CEF* policies related to technological improvements in fossil fuel supply. The average wellhead price of natural gas in 2020 is expected to be reduced from $3.10 per thousand cubic feet in the reference case to $2.48 and $2.36 per thousand cubic feet in the moderate and advanced cases, respectively. In 2020, the average projected minemouth price of coal is reduced from $12.93 per short ton in the reference case to $12.78 and $11.51 per short ton in the *CEF-JL* moderate and advanced cases, respectively. Because oil prices are assumed to be set on world markets, the average crude oil price is not expected to change. In 2020, average electricity prices are expected to be lower in the *CEF-JL* moderate case, 6.0 cents per kilowatthour compared with 6.1 cents per kilowatthour in the reference case, due to the lower price of fossil fuels, but are higher in the *CEF-JL* advanced case, reaching 6.6 cents per kilowatthour, due to the impact of the $50 carbon fee. As a result of lower energy consumption and generally lower prices, energy expenditures are projected to be lower than in the reference case.

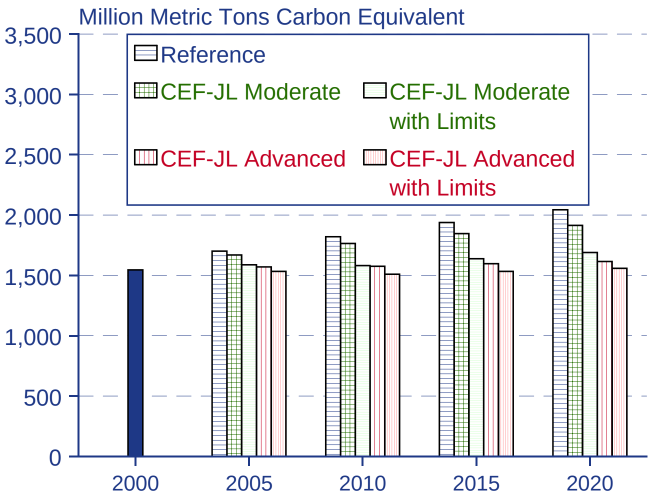
Total projected CO_2 emissions in 2020 are reduced by 130 and 429 million metric tons carbon equivalent, or 6 and 21 percent, in the *CEF-JL* moderate and advanced cases, respectively, due to the lower demand for fossil fuels (Figure 23). Emissions of SO_2, NO_x, and Hg by electricity generators are also generally reduced due to lower projected coal consumption and, in the advanced case, to the policy to reduce particulate emissions (Figures 24 through 26).

With the addition of the emissions limits to the *CEF-JL* cases, primary energy consumption in 2020 is projected to be reduced by 3 percent in the moderate case and 1 percent in the advanced case. In the *CEF-JL* moderate case, the projected decline in energy intensity accelerates from 1.9 percent to 2.0 percent when the emissions limits are added; however, the decline is projected to remain 2.4 percent in the *CEF-JL* advanced case even with the imposition of the emissions limits. Because the *CEF-JL* advanced case already includes a $50 carbon fee, there is little additional reduction in energy demand in that case due to emissions limits on electricity generators, and energy expenditures are similar. In the *CEF-JL* moderate case, higher projected prices for coal, natural gas, and electricity are projected to reduce energy consumption in the residential and commercial sectors when emissions limits are imposed and raise energy expenditures. In the industrial sector, projected energy consumption in 2020 is essentially unchanged because higher demand for natural gas for cogeneration offsets lower demand for purchased electricity. Total projected electricity sales in 2020 are reduced by 7 percent in the *CEF-JL* moderate case when the emissions limits are imposed but is essentially unchanged in the advanced case with the addition of the emissions limits.

In the electricity generation sector, coal-fired generation in 2020 is projected to be reduced by 44 and 19 percent in the moderate and advanced cases, respectively, with the addition of the emissions limits. The impact is less in the advanced case because the advanced case without the limits already includes a $50 carbon fee and particulate reductions. Generation by natural gas, nuclear power, and renewable sources is increased in both cases when the emissions limits are imposed because the limits raise the cost of coal generation.

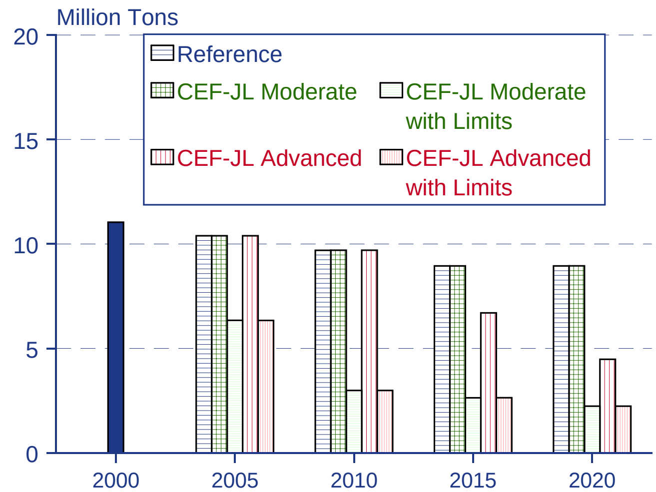
In 2020, total natural gas consumption is projected to be higher by 8 and 4 percent in the *CEF-JL* moderate and advanced cases with the emissions limits, relative to the cases without limits, due primarily to increased natural gas generation and, in the moderate case, to higher cogeneration in the commercial and industrial sectors. As a result, natural gas wellhead prices are projected to be higher by 14 and 11 percent, as production increases to meet demand. Renewable sources of energy are also higher as they become more economical for generation with the emissions limits. Total projected coal consumption is lower by 39 and 16 percent in the moderate and advanced cases with emissions limits, as compared with the respective cases without limits, due to reduced coal-fired generation. Projected petroleum consumption remains unchanged because the emissions limits have a negligible impact on petroleum markets.

Figure 23. Carbon Dioxide Emissions in Five Cases, 2000-2020



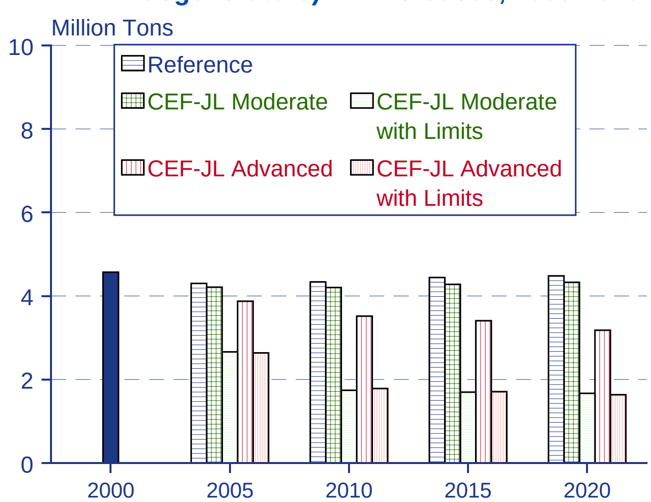
Source: National Energy Modeling System, runs SCENABS. D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 24. Sulfur Dioxide Emissions from Generating Units (Excluding Cogenerators) in Five Cases, 2000-2020



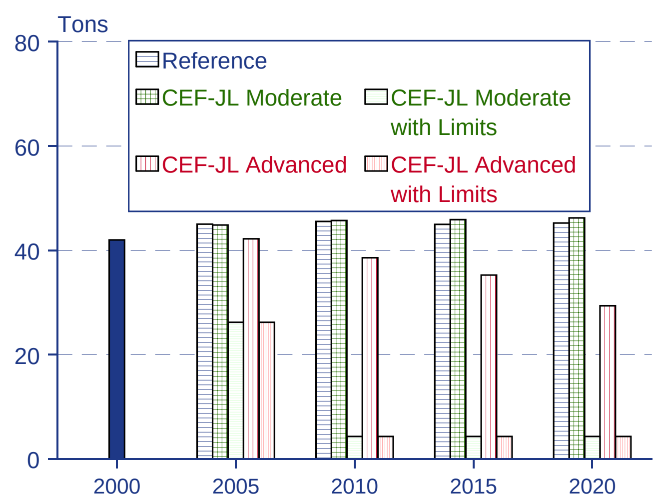
Source: National Energy Modeling System, runs SCENABS. D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 25. Nitrogen Oxides Emissions from Generating Units (Excluding Cogenerators) in Five Cases, 2000-2020



Source: National Energy Modeling System, runs SCENABS. D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 26. Mercury Emissions from Generating Units (Excluding Cogenerators) in Five Cases, 2000-2020



Source: National Energy Modeling System, runs SCENABS. D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Average delivered electricity prices are expected to be higher in 2020 in the *CEF-JL* moderate case when emissions limits are imposed, 7.2 cents per kilowatthour compared with 6.0 cents per kilowatthour. The cost to electricity generators of meeting the emissions limits by installing emissions control equipment or purchasing emissions permits is included in the price of electricity, to the extent to which these costs can be passed through to consumers. CO_2 emissions permit costs are effectively included in the price of the fossil fuel to electricity generators. For the other three emissions, the permit costs are included in the electricity price based on the cost incurred by the marginal generator. However, projected electricity prices remain unchanged in the advanced case with emissions limits in 2020 in part due to lower SO_2 allowance costs. The cost of allowance permits for SO_2 in 2020 is projected to be higher in the moderate case with emissions limits due to the cost of additional emission control equipment constructed to reduce both SO_2 and Hg emissions. However, the permit cost is projected to be lower in the advanced case with emissions limits, compared to the case without limits, because limits on CO_2 emissions lower coal use and reduce the need to switch to lower-sulfur coal or natural gas or install scrubbers.

The projected costs for NO_x permits decrease to zero by 2020 in the *CEF-JL* advanced case with emissions limits as actions taken to reduce CO_2 emissions result in NO_x emissions within the limits. The projected allowance costs for Hg emissions reach $468 and $391 million per ton in 2020, in the *CEF-JL* moderate and advanced cases with emissions limits, reflecting the cost of adding emission control equipment. Allowance costs for CO_2 are projected to be $68 and $50 per metric ton carbon equivalent in the moderate and advanced cases with emissions limits, respectively. In the advanced case with the emissions limits, the CO_2 allowance cost is essentially the same as in the advanced case without the limits.

Between 2001 and 2020, the cumulative incremental resource costs to electricity generators to comply with the emissions limits are $162 billion and $129 billion in the moderate and advanced cases, respectively— 9- and 8-percent increases relative to the cases without emissions limits. The lower additional costs of compliance in the advanced case are due to lower electricity demand in the advanced case, the availability of more efficient generating technologies, and the lower SO_2 emissions as a result of the particulate reduction policy assumed in the advanced case without emissions limits.

Total projected CO_2 emissions in 2020 are reduced by 224 and 57 million metric tons carbon equivalent, or 12 and 4 percent, in the *CEF-JL* moderate and advanced cases with emissions limits, respectively, compared to the cases without the limits, primarily due to lower coal generation. The smaller reduction in the *CEF-JL* advanced case with emissions limits is due to the $50 carbon fee assumed in the *CEF-JL* advanced case without limits, which provides most of the reduction in CO_2.

Residential

The *CEF* study presented eight general categories of polices to remove barriers to technology adoption and reduce energy costs, energy use, and CO_2 emissions in both residential and commercial buildings. Residential sector energy and CO_2 reductions were attributed to equipment standards, voluntary programs, tax credits, building codes, and research and development programs.

The analysis of the programs was conducted through a detailed spreadsheet analysis for both the moderate and advanced cases. The projections in the spreadsheet analysis were then matched in *CEF*-NEMS through changes to consumer hurdle rates, technology costs, and growth trends for each end use. The changes reportedly "reflect the effect of a variety of non-energy-price policies that eliminate many of the barriers to investing in cost-effective efficiency technologies."[33] The *CEF-JL* moderate and advanced cases include many changes to the reference case, including future appliance standards, lower growth rates for miscellaneous electric devices, lower costs for high efficiency appliances, lower consumer hurdle rates, and increases in building shell efficiency. The implementation of each of these changes and its impact on the reference case is described below.

CEF Residential Appliance Standards

Updates to Federally-mandated appliance standards were a major policy in the *CEF* study. In the *CEF* moderate and advanced cases, the standards credited with savings are listed in Table 15.

For the implementation of the *CEF* standards in the *AEO2001* version of NEMS, changes were made to conform to the standards that were announced in January 2001 and, in the case of central air conditioners and heat pumps, subsequently revised by the Bush Administration. The 2010 standards for room air conditioners and refrigerators have not been announced and therefore are not included in the reference case, but are included for the *CEF-JL* cases. The standards implemented in NEMS for these two cases are shown in Table 16.

The refrigerator standard represents about a 12-percent decline in the amount of electricity used per unit relative

[33] Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), web site www.ornl.gov/ORNL/Energy_Eff/CEFOnep.pdf.

to the current standard. The room air conditioner standard represents about an 8-percent increase in efficiency over the current standard. All of the other standards are included in the reference case because these standards have been approved since *AEO99*, thus there are no additional energy savings in the *CEF-JL* moderate and advanced cases due to these standards.

CEF Residential Miscellaneous Electricity Growth Rates

The reduction in the growth rates for miscellaneous electric appliances incorporated in the *CEF* study clearly had the largest impact on projected electricity demand. Miscellaneous electricity uses consist of a variety of smaller end uses not individually identified. Major uses of electricity in the residential sector include space heating, space cooling, water heating, refrigeration, cooking, and lighting. By 2010, nearly 65 percent of the projected electricity savings in the *CEF* moderate case was attained by reducing the demand for miscellaneous electric appliances. These appliances include stereo systems, battery chargers, bread makers, and waterbed heaters, as a few examples. Given the way these appliances are used and the fact that many cannot incorporate increased energy efficiency into their design, for example, the heating elements found in many small cooking products, it is difficult to credit this magnitude of electricity savings from voluntary programs and State market transformation programs, as stated in the *CEF* report. The growth in miscellaneous electricity use is dictated by the increasing saturation of relatively new products into the residential sector. It is unclear how market transformation programs or voluntary programs could reduce the natural acceptance of these new products. Some voluntary programs, such as the effort to convince manufacturers to produce electronic equipment with no more than 1 watt of standby power, can have some effect on these growth rates. The standby power, however, contributes less in terms of the increased electricity growth than the active power, thus the growth rates would likely not be affected as much as the *CEF* study claims.

By incorporating the *CEF* assumptions for the moderate and advanced cases, projected electricity use for electronics, the fastest growing component of miscellaneous electricity use, is reduced by 22 and 24 percent in 2010, respectively, relative to the reference case. The reductions in 2020 for the moderate and advanced cases are 55 and 82 percent, respectively, effectively negating any growth in miscellaneous electricity consumption from 2000 to 2020 in the advanced case. From 1990 to 1997, EIA data indicate that miscellaneous electricity use per household increased 70 percent.[34] Given the historical growth for miscellaneous electricity use, it is improbable that efficiency gains could be achieved that would nearly stop all growth in electricity consumption for these appliances over the next 20 years. Table 17 details the percentage reduction in miscellaneous electricity

Table 15. Residential Appliance Efficiency Standards Credited with Savings in *CEF*

Appliance	Standard	Year Implemented
Central Air Conditioners and Heat Pumps	13 SEER	2006
Room Air Conditioners	10.5 EER	2010
Clothes Washers	Horizontal Axis, 1.26 MEF	2006
Natural Gas Hot Water Heaters	0.60 EF	2004
Electric Hot Water Heaters	0.95 EF	2004
Refrigerators (Advanced Case Only)	421 kilowatthours per year	2010

Note: EF is energy factor (Btu out per Btu in); SEER is seasonal energy efficiency ratio (Btu out per watthour in); MEF is modified energy factor (cubic foot per kilowatthour per cycle); EER is energy efficiency ratio (Btu out per watthour in).
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table 16. Residential Appliance Efficiency Implemented in *CEF-JL* Moderate and Advanced Cases

Appliance	Standard	Year Implemented	Comments
Central Air Conditioners and Heat Pumps	12 SEER	2006	January 2001 standard, revised by Bush Administration
Room Air Conditioners	10.5 EER	2010	*CEF* policy
Clothes Washers (First Tier)	1.04 MEF	2004	January 2001 standard
Clothes Washers (Second Tier)	Horizontal Axis, 1.26 MEF	2007	January 2001 standard
Natural Gas Hot Water Heaters	0.59 EF	2004	January 2001 standard
Electric Hot Water Heaters	0.90 EF	2004	January 2001 standard
Refrigerators (Advanced Case Only)	421 kilowatthours per year	2010	*CEF* policy

Note: EF is energy factor (Btu out per Btu in); SEER is seasonal energy efficiency ratio (Btu out per watthour in); MEF is modified energy factor (cubic foot per kilowatthour per cycle); EER is energy efficiency ratio (Btu out per watthour in).
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

[34] Energy Information Administration, Residential Energy Consumption Survey 1990 and 1997, DOE/EIA-0321.

uses in the moderate and advanced cases, relative to the reference case.

CEF Residential Consumer Hurdle Rates

In the reference case, consumer hurdle rates, or the willingness to invest in energy efficiency, vary by appliance type and accordingly influence the efficiency level in a given year for a given appliance. The hurdle rates used in NEMS represent all of the observed and unobserved factors that bring about the average level of efficiency for each major appliance purchased in the marketplace. Although discount rates are defined as a financial premium on investments, the hurdle rates observed in the marketplace are influenced mostly by nonfinancial factors. For example, consumers tend to value an ice maker or other features of a refrigerator more than the expected annual cost to run the appliance over a given time period. Since refrigerators with these features generally use more electricity than those without them, the observed market hurdle rate appears high. For most products, energy efficiency plays a small role in the decisionmaking process for purchasing new appliances, causing large observed hurdle rates.

Estimates for consumer hurdle rates are based on shipment data, which reveal the average purchased efficiency for various appliances on a yearly basis. These data, coupled with cost and performance estimates for these appliances, allow for estimates of consumer hurdle rates. Since the reasons for purchasing equipment of various efficiency levels are not fully known, all of the factors that relate to consumer choice are bundled into the hurdle rate.

In the NEMS residential module, these estimated consumer hurdle rates range from 15 to over 100 percent, depending on the appliance, reflecting the importance of nonfinancial features in appliance purchases. In the *CEF* moderate and advanced cases, consumer hurdle rates for all major appliances were assumed to be 15 percent. This assumption essentially means that all nonfinancial factors were removed from the decisionmaking process. Since many of these purchases are financed through credit card accounts with rates above 15 percent and since many purchases are made by building owners or builders who do not pay the energy bill, this assumption seems very optimistic. By setting the consumer hurdle rates to 15 percent, more rapid adoption of the more efficient technologies was projected in the moderate and advanced cases in *CEF*, especially when coupled with the changes in the costs of the technologies described below. For the *CEF-JL* cases, the *CEF* hurdle rates are used.

Table 17. Reductions in Residential Miscellaneous Electricity Use in the *CEF* Moderate and Advanced Cases, Relative to the Reference Case, 2010 and 2020
(Percent)

Use	*CEF* Moderate Case		*CEF* Advanced Case	
	2010	2020	2010	2020
Electronics	22	55	24	82
Heating Elements. .	8	11	8	11
Motors	9	19	9	22
Lighting	1	10	10	56
Color Televisions . .	8	17	8	25
Furnace Fans.	0	8	2	26

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

CEF Technology Costs for Efficient Residential Equipment

In the *CEF* moderate and advanced cases, numerous changes were made to the costs, efficiencies, and the dates of availability for most technologies in the *AEO99* reference case. For some appliances, the cost of the most efficient unit available for purchase was reduced to equal the cost of the least efficient unit. For example, in the *CEF* advanced case, a central air conditioner with a 70 percent greater efficiency than the least efficient unit was offered at the same price as the least efficient unit from 2011 through 2020. It seems highly unlikely that increases in research and development funding or the success of voluntary programs could bring about this change in the relative prices of various appliances in such a short time span considering the need to obtain additional Federal funding, conduct successful research and development, and achieve market acceptance. In the advanced technology case, which assumes greater adoption of more efficient technologies, the cost of a unit with similar efficiency characteristics costs nearly 30 percent more than in the *CEF* advanced case. In the EIA implementation of the *CEF* cost and efficiency characteristics for the *CEF-JL* cases, the same values are used for each case as in the *CEF* analysis. Table 18 shows some of the costs and efficiencies of various residential appliances across the four cases in this report.

Given the costs assumed in the *CEF* study, there are no cost increases to the consumer for the most efficient products. The *AEO2001* best available technology case, which assumes the purchase of only the most efficient technology available throughout the projection period, forecasts a similar level of demand as in the *CEF* advanced case.[35] To attain this lower level of demand, the *AEO2001* best available technology case requires a

[35]Energy Information Administration, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001)(Washington, DC, December 2000), pp. 216-217. Because energy investments for shell improvements are not computable, energy savings from these improvements have been removed from the best available technology case to allow for a comparison of the best available technology case in *AEO2001* and the *CEF* advanced case.

projected cumulative incremental investment by residential consumers of $179 billion through 2010 and of $355 billion through 2020. The *CEF* advanced case, however, projected a cumulative incremental investment of only $15 billion through 2010 and $47 billion through 2020 due to assumptions about lower costs for the most efficient technologies available, due to research and development and State and voluntary programs. This represented a dramatic difference in the costs required to save roughly the same amount of energy in the residential sector.

CEF Changes for Residential Building Shell Efficiency

The final set of changes implemented in the *CEF* study involved policies aimed at increasing the efficiency of building shells. The interaction of many building components, such as windows, insulation, and foundation type, affect the overall efficiency of the structure. Several policies can impact the heating and cooling loads of residential buildings, especially new construction. Stricter building codes, the Energy Star Homes program (ESTAR), tax credits, and the Partnership for the Advancement of Technology in Housing (PATH) are examples of policies which could significantly impact the efficiency and energy consumption for heating and cooling in new houses.

The *CEF* study considered all of the policies listed above in its analysis for both the moderate and advanced cases. The impact of these policies was calculated separately. For the moderate case, it was determined that the *AEO99* reference case projections for shell efficiency improvements in new houses were sufficiently represented for the amount of efficiency gain expected from the policies, and no changes were made. In the advanced case, the *CEF* authors assumed that the shell efficiency for new houses would improve 10 percent by 2010 and 30 percent by 2020, relative to the reference case, based on assumptions regarding the effects of tax credits, building codes, and voluntary programs. Relative to the homes built in *AEO99* in 2000, these changes resulted in new homes that were 19 percent more efficient in 2010 and 47 percent more efficient in 2020. This essentially meant that every home built in 2020 would meet the goals of the PATH program, which strives to build homes that are 50 percent more efficient than current code.

The *AEO2001* version of the NEMS residential module allows for a direct implementation of the policies listed above. Several shell efficiency levels, including ESTAR and PATH, are explicitly represented as an economic choice to the consumer, allowing for tax credits and technological learning. The learning function allows the costs for the more efficient and more costly building shells to decline over time, as builders become more familiar with the techniques and equipment required to meet the higher levels of building shell efficiency. In the *CEF-JL* moderate case, no changes are made to any of the shell parameters, since none were made in the *CEF* study. In the *CEF-JL* advanced case, however, tax credits and changes in consumer hurdle rates are applied to the reference case to represent the changes made in the advanced case for the *CEF* study. By implementing these

Table 18. Cost and Efficiency of Various Residential Technologies, 2015
(Costs in 1991 Dollars, Efficiency Given as an Index, Where Least Efficient Unit Available Equals 1.00)

Technology	Reference		Advanced Technology		*CEF-JL* Moderate		*CEF-JL* Advanced	
	Cost	Efficiency	Cost	Efficiency	Cost	Efficiency	Cost	Efficiency
Air-Source Heat Pump (Heating)								
Least Efficient	3,700	1.00	3,700	1.00	3,700	1.00	3,700	1.00
Most Efficient	4,400	1.33	4,400	1.46	4,300	1.33	3,700	1.82
Natural Gas Furnace								
Least Efficient	750	1.00	750	1.00	750	1.00	750	1.00
Most Efficient	900	1.23	900	1.23	680	1.23	750	1.23
Central Air Conditioner								
Least Efficient	1,800	1.00	1,800	1.00	1,800	1.00	1,800	1.00
Most Efficient	2,300	1.50	2,300	1.50	1,800	1.60	1,800	1.70
Electric Hot Water Heater								
Least Efficient	257	1.00	257	1.00	225	1.00	225	1.00
Most Efficient	825	2.89	825	3.11	400	2.44	400	2.44
Natural Gas Hot Water Heater								
Least Efficient	300	1.00	300	1.00	190	1.00	190	1.00
Most Efficient	1,500	1.46	1,500	2.37	1,500	1.46	225	1.46
Refrigerators[a]								
Least Efficient	480	1.00	480	1.00	480	1.00	480	1.00
Most Efficient	700	0.84	700	0.63	480	0.52	480	0.36

[a]Refrigerator efficiency index given in terms of electricity use per unit. As the value decreases, the efficiency of the unit increases.
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

changes, homes built in 2010 are projected to be 15 percent more efficient relative to new homes built in 2000, while those built in 2020 are projected to be 19 percent more efficient. Thus, the *CEF-JL* advanced case projects only a slightly lower efficiency improvement in 2010 compared to the advanced case in the *CEF* analysis, but a much lower efficiency improvement, less than half, in 2020 based on the same shell efficiency assumptions.

Impact of *CEF* Policies on Residential Demand

Given the extensive data and modeling changes needed to replicate the *CEF* cases, the *CEF-JL* moderate and advanced cases have significant changes in residential energy demand, relative to the reference case. Delivered energy consumption in 2010 is projected to be lower by 2 and 6 percent in the *CEF-JL* moderate and advanced cases, respectively, relative to the reference case, as increased efficiency, changes in consumer behavior, and the $50 carbon fee in the advanced case significantly reduce the amount of energy, particularly electricity, needed to power appliances (Table 19). In 2020, the relative reductions in projected residential consumption in the *CEF-JL* moderate and advanced cases are 7 and 14 percent.

As noted above, the assumed reduction in the growth of miscellaneous electric devices in the *CEF-JL* cases has the largest impact on projected energy consumption. By 2020, projected electricity consumption is reduced by 16 and 26 percent in the *CEF-JL* moderate and advanced cases, respectively, relative to the reference case. Residential CO_2 emissions are projected to decrease by 35 and 111 million metric tons carbon equivalent, or 9 and 29 percent, in 2020 in the *CEF-JL* moderate and advanced cases, respectively, compared to the reference case.

Impact of Emissions Limits on Residential Demand in the *CEF-JL* Cases

Due to the lower level of projected energy demand in the *CEF-JL* moderate and advanced cases, relative to the other cases, the impact of emissions limits on energy

Table 19. Residential Sector Projections in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
				2010		
Delivered Energy Consumption (Quadrillion Btu)	**10.7**	**12.2**	**11.9**	**11.6**	**11.4**	**11.3**
Electricity	3.9	4.9	4.6	4.4	4.4	4.3
Natural Gas	4.9	5.5	5.5	5.4	5.4	5.3
Petroleum	1.4	1.3	1.3	1.3	1.2	1.2
Delivered Prices (1999 Dollars per Million Btu)	**13.18**	**13.41**	**12.80**	**14.17**	**13.32**	**13.85**
Electricity	23.69	22.19	21.52	24.81	23.31	24.02
Natural Gas	6.52	6.70	6.39	6.81	6.26	6.69
Petroleum	7.55	9.37	9.36	9.27	8.95	9.10
Effective Delivered Prices[a] (1999 Dollars per Million Btu)	**13.18**	**13.41**	**12.80**	**14.17**	**13.78**	**14.31**
Electricity	23.69	22.19	21.52	24.81	23.31	24.02
Natural Gas	6.52	6.70	6.39	6.81	6.98	7.41
Petroleum	7.55	9.37	9.36	9.27	9.89	10.04
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**290**	**346**	**333**	**267**	**285**	**262**
				2020		
Delivered Energy Consumption (Quadrillion Btu)	**10.7**	**13.5**	**12.6**	**12.2**	**11.6**	**11.5**
Electricity	3.9	5.7	4.8	4.5	4.2	4.2
Natural Gas	4.9	6.1	6.1	6.0	5.8	5.7
Petroleum	1.4	1.2	1.2	1.2	1.1	1.1
Delivered Prices (1999 Dollars per Million Btu)	**13.18**	**13.62**	**12.74**	**13.88**	**12.98**	**13.20**
Electricity	23.69	22.16	22.32	25.20	24.00	24.06
Natural Gas	6.52	6.56	5.98	6.32	5.88	6.15
Petroleum	7.55	9.47	9.38	9.26	9.02	9.07
Effective Delivered Prices[a] (1999 Dollars per Million Btu)	**13.18**	**13.62**	**12.74**	**13.88**	**13.46**	**13.67**
Electricity	23.69	22.16	22.32	25.20	24.00	24.06
Natural Gas	6.52	6.56	5.98	6.32	6.59	6.87
Petroleum	7.55	9.47	9.38	9.26	9.96	10.01
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**290**	**383**	**348**	**271**	**272**	**254**

[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

prices is relatively small (Figure 27). In 2020, the imposition of emissions limits in the *CEF-JL* advanced case has relatively little impact on projected residential energy prices, as electricity generators meet the emissions limits with relative ease. In 2010, however, residential electricity prices are projected to increase by 15 percent in the *CEF-JL* moderate case and 3 percent in the *CEF-JL* advanced case when the emissions limits are imposed, due in part to the short lead-time allowed for the more efficient equipment to enter into the stock.

In all cases, if the emissions limits on electricity generators cause projected electricity prices to increase, projected consumption of electricity by the residential sector decreases. In 2010, due to the increase in the projected price of electricity when the limits are imposed, electricity consumption is projected to be lower by 5 percent in the *CEF-JL* moderate case and by 1 percent in the *CEF-JL* advanced case. In 2020, the comparable reduction in projected electricity consumption is 5 percent in the *CEF-JL* moderate case. In 2020, projected electricity consumption is the same in the *CEF-JL* advanced case when the emissions limits are imposed on electricity generators because electricity prices are very similar. In 2020, projected CO_2 emissions from the residential sector are reduced by 77 and 18 million metric tons carbon equivalent, or 22 and 7 percent, in the *CEF-JL* moderate and advanced cases with the emissions limits, compared to the cases without the limits, primarily due to reductions in electricity consumption.

Commercial

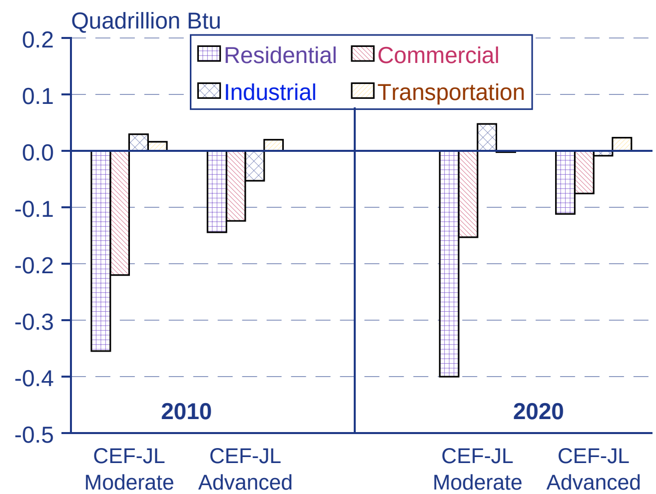
Commercial sector energy and CO_2 savings reported in the *CEF* study were attributed to five categories of policies, equipment standards, commercial building codes, voluntary programs, research and development programs, and a utility program featuring heat pump water heaters. Similar to the residential sector, in the *CEF* study these programs were analyzed separately, and the results were then incorporated into *CEF*-NEMS, through lower growth rates for miscellaneous electric devices, lower costs for high efficiency appliances, lower consumer hurdle rates, and efficiency increases for miscellaneous uses of natural gas. For this study, the changes for the *CEF* policies were implemented in the same manner as in the *CEF* study, as described below.

CEF Commercial Appliance Standards

Updates to Federally-mandated commercial appliance standards accounted for 31 and 28 percent of projected commercial energy savings in 2010 for the moderate and advanced cases in the *CEF* study, respectively. The standards credited with savings in these cases are listed in Table 20.

The purpose of a standard is to mandate a minimum efficiency level for a particular class of equipment. After the date that a standard becomes effective, manufacturers can no longer make equipment that does not meet the level of efficiency mandated by the standard. Although represented as standards in the separate *CEF* analysis, the items in Table 20 were not strictly implemented as standards in *CEF*-NEMS. Specifically, heating, cooling, and lighting technologies meeting the standard levels were made available in the appropriate years; however, models of equipment that did not meet the mandated efficiency levels were allowed to remain

Figure 27. Impact of Emissions Limits on Delivered Energy Consumption in Two Cases, 2010 and 2020



Source: National Energy Modeling System, runs SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Table 20. Commercial Appliance Efficiency Standards Credited with Savings in *CEF*

Appliance	Standard	Year Implemented
Packaged Air Conditioners	10.3 EER	2005
Packaged Air Conditioners (Advanced Case Only)	11 EER	2010
Natural Gas Furnace and Boiler (Advanced Case Only)	0.82 combustion efficiency	2010
Fluorescent Ballasts	Electronic	2004
Transformer Standard (Advanced Case Only)	65 kilowatthours per year	2004

Note: EER is energy efficiency ratio (Btu out per watthour in).
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

on the market through 2020. The transformer standard was not implemented in *CEF*-NEMS because transformers are not explicitly represented.

Table 21 shows the updated commercial standards represented in the *CEF-JL* moderate and advanced cases. Changes were made to the *CEF* study assumptions to conform to the fluorescent ballast standard announced by the Department of Energy (DOE) in September 2000 and additional standards that were announced by DOE in January 2001. The standards announced by DOE are represented as true standards in the *CEF-JL* cases and in the reference case, i.e., only equipment that meets the standard is available for purchase after its effective date. The standards for air-cooled packaged air conditioners and the 2010 standard for natural-gas-fired furnaces and boilers have not been announced and therefore are not included in the reference case but are implemented in the *CEF-JL* cases as in the *CEF* analysis.

The 2005 packaged air conditioner standard represents about a 16-percent increase in efficiency over the current standard. The 2010 packaged air conditioner standard and the natural gas furnace and boiler standard in the advanced case represent about 23.6 and 2.5-percent increases in efficiency, respectively, relative to the current standard. These standards were implemented as in the *CEF* study, so that models of equipment with efficiency ratings that do not meet the reported standard remain available through 2020. Since the transformer standard was not implemented in the advanced case in the *CEF* study because transformers are not explicitly represented, the same is done in this study. All of the other standards are included in the reference case, thus there are no additional energy savings in the moderate or advanced cases due to these standards.

CEF Commercial Miscellaneous Electricity Growth Rates

Adjustments regarding the amount of electricity used by miscellaneous commercial applications in the *CEF* study had a significant impact on projected electricity demand. Miscellaneous energy uses consist of a variety of smaller end uses not individually identified. In the commercial sector, major uses of energy include space heating, space cooling, water heating, refrigeration, cooking, lighting, ventilation, and office equipment. Miscellaneous uses include all other uses, such as telecommunications and medical equipment, exit signs, transformers, and automated teller machines. By 2010, 58 percent of the projected commercial electricity savings in the *CEF* moderate case was achieved by reducing miscellaneous electricity demand. The miscellaneous electricity savings in the *CEF* study were attributed strictly to voluntary programs in the moderate case, specifically Energy Star exit signs, transformers, and traffic lights. Savings in the *CEF* advanced case were attributed to a 2004 transformer standard in addition to the Energy Star programs although the standard was not implemented in *CEF*-NEMS.

It is difficult to credit this magnitude of electricity savings from voluntary programs given the variety of uses for electricity in this category, such as telecommunications equipment, automated teller machines, and medical equipment. Although there is the potential for some efficiency improvements, it is unlikely that efficiencies could improve enough to reach the consumption levels achieved in *CEF*. In addition, the incremental cost for energy-efficient equipment can be substantial. For example, TP 1/Energy Star transformers are readily available from several major manufacturers; however,

Table 21. Commercial Appliance Efficiency Implemented in *CEF-JL* Moderate and Advanced Cases

Appliance	Standard	Year Implemented	Comments
Packaged Air Conditioners	10.3 SEER	2005	Implemented in *CEF-JL* moderate and advanced cases, identical to implementation in *CEF* study
Packaged Air Conditioners	11 SEER	2010	Implemented in *CEF-JL* advanced case, identical to implementation in *CEF* study
Natural Gas Furnace	0.75 percent casing loss	2003	Implemented in *CEF-JL* moderate and advanced cases and in reference case, announced by DOE in January 2001, not included in *CEF* study
Natural Gas Furnace and Boiler	0.82 combustion efficiency	2010	Implemented in *CEF-JL* advanced case, identical to implementation in *CEF* study
Natural Gas Water Heater	0.80 TE	2003	Implemented in *CEF-JL* moderate and advanced cases and in reference case, announced by DOE in January 2001, not included in *CEF* study
Fluorescent Ballasts	Electronic	2005	Implemented in *CEF-JL* moderate and advanced cases and in reference case, announced by DOE in September 2000, implemented one year later than in *CEF* study

Note: SEER is seasonal energy efficiency ratio (Btu out per watthour in); TE is thermal efficiency (Btu out per Btu in).
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

cost premiums over conventional models range from 50 to 100 percent, depending on size.[36] The savings estimated for transformers and exit signs were thought to be "particularly important" in the *CEF* study. Although savings were attributed to miscellaneous uses of electricity in the *CEF* study and calculated in the spreadsheet analysis, modifications made to the growth rate of miscellaneous uses in *CEF*-NEMS were not attributed to policies. The *CEF* study stated that "[the] changes are not policy induced . . . . [T]he energy savings from the stand-alone *CEF*-NEMS runs fell short of those in our off-line analysis even after implementing the source code and input file changes . . . ."[37] The penetration rate for "other end uses" of electricity was adjusted ". . . [i]n order to match total forecast electricity savings with our off-line accounting . . . ."[38] The adjustments made to affect the growth rate of miscellaneous electricity use in *CEF*-NEMS are summarized in Table 22. The same adjustments to the penetration rate for "other end uses" of electricity are incorporated for the *CEF-JL* moderate and advanced cases, reducing projected miscellaneous electricity use by 10 percent in 2010, in both cases, relative to the reference case and by 22 and 26 percent, respectively, in 2020.

CEF Commercial Miscellaneous Natural Gas Growth Rates

In addition to adjusting the penetration rate for other uses of electricity, an annual efficiency increase for other natural gas consumption was included in the moderate and advanced cases in the *CEF* analysis to "calibrate energy consumption to [*CEF*] off-line analysis estimates in 2010 and 2020."[39] Again, this change was not attributed to any specific policy. The efficiency of other natural gas consumption was increased 1 percent per year between 2001 and 2010 for both the moderate and advanced cases. The efficiency improvement was increased between 2011 and 2020 to 4 percent per year in the moderate case and 16 percent per year in the advanced case. The increase of 1 percent per year from 2001 through 2010 could be attributed to success of voluntary programs in encouraging the adoption of more efficient natural-gas-fired equipment. However, projecting a 16-percent improvement in efficiency each year for ten years seems extremely optimistic considering the variety of uses included in the category, ranging from electricity generators to commercial laundry equipment to swimming pool heaters, and the slow turnover rate in the stock of most commercial equipment. Nevertheless, the same efficiency improvements in other natural gas consumption are implemented in the *CEF-JL* cases.

Table 22. Adjustments to the Penetration Rate of Commercial Miscellaneous Electricity Use in the *CEF* Moderate and Advanced Cases, Relative to the Reference Case, 2010 and 2020
(Percent)

Use	*CEF* Moderate Case		*CEF* Advanced Case	
	2010	2020	2010	2020
Other End Uses of Electricity	-28	-45	-28	-52

Source: Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), Appendix A1, web site www.ornl.gov/ORNL/Energy_Eff/CEF-A1.pdf.

CEF Commercial Consumer Hurdle Rates

In the reference case, a distribution of consumer hurdle rates for each major end-use service represents the willingness of commercial consumers to invest in energy efficiency. Not all consumers will have the same requirements and priorities when purchasing equipment, and in practice, the average hurdle rates observed are often much higher than the cost of borrowing money for a variety of reasons. Limited availability of investment funds and the desire for particular features, such as choosing more product space over more insulation in a refrigerated display case, are examples of reasons for high hurdle rates. The distribution of commercial hurdle rates in the reference case ranges from the 10-year Treasury Bill rate used by the Federal sector when making purchase decisions to a rate that minimizes the installed capital costs of equipment.

In the *CEF* moderate and advanced cases, modifications were made to the hurdle rates for all major commercial end-use services. For several end uses, hurdle rates were reduced to the financial component for 2011 through 2020, eliminating all other aspects, such as transaction and information costs, that factor into a purchase decision. This change reflected "a world in which aggressive programs and policies remove barriers to adoption of energy-efficient technologies through the success of voluntary programs and increased funding for research and development." Additional modifications were

[36]A. Hinge, M. Suozzo, T. Jones, D. Korn, and C. Peverell, *Market Transformation for Dry-Type Distribution Transformers: The Opportunity and the Challenges*, Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings / 6.191 (Washington, DC; American Council for an Energy-Efficient Economy, August 2000)

[37]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL / CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), Appendix A1, pp. A-1.14 and A-1.16, web site www.ornl.gov / ORNL / Energy_Eff / CEF-A1.pdf.

[38]*Ibid.*

[39]*Ibid.*, p. A-1.13.

made to the share of consumers that could potentially switch technology and/or fuel types when hurdle rate changes were not sufficient to reach the desired energy savings. Space heating, space cooling, and ventilation end uses were all affected to varying degrees by modifications to decision rule shares. Reference case shares are based on the proportions of government, privately owned, and leased space in EIA's Commercial Buildings Energy Consumption Survey and estimates of self-built versus speculative developer space for new construction.

A large part of the savings from the hurdle rate and decision rule changes was attributed to voluntary programs, such as Energy Star buildings and Rebuild America. The *CEF* study credited voluntary programs with 52 percent and 49 percent of 2010 commercial energy savings in the moderate and advanced cases, respectively. Whole building research and development programs were assumed to make other policies, such as voluntary programs, less expensive and therefore increased their penetration. In addition, utility programs for heat pump water heaters were credited with savings in the *CEF* study. Presumably, part of the savings from the changes in hurdle rates was attributed to these programs. Since energy may be a small part of the cost of owning and operating a building and since building owners who do not pay the energy bill make many of the initial purchases, these assumptions seem very optimistic and may not be representative of real markets. In implementing the *CEF* assumptions for the *CEF-JL* cases, however, hurdle rates are set to the values described in the *CEF* study in accordance with the request for this analysis.

CEF Savings for Commercial Building Shell Efficiency

The *CEF* study included a set of policies aimed at increasing the efficiency of building shells. The interaction of many building components, such as windows, insulation, and foundation type, affected the overall efficiency of the structure. Several policies can impact the heating and cooling loads of commercial buildings. A new standard for commercial building codes, the Energy Star Buildings and Rebuild America programs, and whole building research and development for new buildings were all policies which could significantly impact the efficiency and energy consumption for heating and cooling in commercial buildings.

The *CEF* study considered all of the policies listed above in its analysis for both the moderate and advanced cases. The impact of these policies was calculated separately, since the *AEO99* version of NEMS did not allow a direct method of implementing the prescribed policies. No changes were made to the *AEO99* reference case projections to incorporate additional commercial building shell efficiency improvements credited with savings in the *CEF* moderate and advanced cases. Presumably, part of the savings from the hurdle rate and decision rule changes was attributed to increased building shell efficiency through adoption of new building codes and the success of the programs specified above. Because no specific changes in commercial building shell efficiency were implemented in *CEF*-NEMS, no specific changes are implemented in the *CEF-JL* cases.

Impact of *CEF* Policies on Commercial Demand

In the *CEF-JL* moderate and advanced cases, commercial delivered energy consumption is projected to be 4 and 5 percent lower in 2010, respectively, relative to the reference case, and 8 and 11 percent lower in 2020 (Table 23). Reduced demand for electricity is projected to account for 86 percent of the 2010 energy savings in the moderate case and 79 percent in the advanced case. In 2020, the projected savings attributed to electricity demand are 88 and 80 percent in the moderate and advanced cases. Changes in consumer behavior and a reduction in the growth of miscellaneous uses of electricity are projected to provide the most significant impact on commercial energy use and resulting commercial sector CO_2 emissions in both cases because few changes are assumed for commercial equipment efficiency for the *CEF-JL* cases. The $50 carbon fee in the advanced case has an additional impact.

Projected demand for purchased electricity is further reduced by 2020 due to increased adoption of distributed generation technologies. The commercial sector is projected to generate an additional 0.8 and 2.5 billion kilowatthours of electricity in 2020 (6 and 19 percent) in the moderate and advanced *CEF-JL* cases, respectively, compared to the reference case. This result is a departure from the *CEF* study because distributed generation in the commercial sector was not represented in the *AEO99* version of NEMS that was the basis of the *CEF* study. The projected reductions in CO_2 emissions attributable to the commercial sector in 2020 are 31 and 86 million metric tons carbon equivalent, or 9 and 25 percent, for the moderate and advanced cases, respectively, relative to the reference case.

Impact of Emissions Limits on Commercial Demand in the *CEF-JL* Cases

The introduction of emissions limits is projected to have a larger impact on commercial electricity prices, and hence, electricity use and CO_2 emissions in the moderate case than in the advanced case. Small additional savings are achieved when the emissions limits are applied to the advanced case, which assumes a carbon fee even without the emissions limits. In the advanced *CEF-JL* case with emissions limits, CO_2 emissions associated with commercial energy use are projected to be lower by 23 and 21 million metric tons carbon equivalent (9 and 8 percent) in 2010 and 2020, respectively, relative to the same case without emissions limits. The larger projected price increase that occurs in the moderate *CEF-JL* case with emissions limits results in projected reductions in CO_2 emissions of 62 and 74 million metric tons carbon equivalent, or 21 and 23 percent, in 2010 and 2020, respectively, due to the price increase caused by the emissions limits. Increased use of distributed generation is a major factor in reducing purchased electricity demand in the moderate *CEF-JL* case with emissions limits, with an additional 1.3 and 19.1 billion kilowatt-hours (17 and 134 percent) of electricity generation projected in 2010 and 2020, respectively.

Industrial

In the industrial sector, six categories of policies were included in the *CEF* study:

- Voluntary industrial sector agreements
- Voluntary programs, e.g., Motor Challenge
- Information programs, e.g., expanding the number of industrial assessment centers
- Investment enabling programs, e.g., tax incentives
- Regulations, e.g., motor standards
- Research and development programs.

For these policies, the advanced case differed from the moderate case only in terms of the scope or magnitude. The moderate case assumed an approximate 50 percent increase in funding from existing levels for the policies, and the advanced case assumed an approximate 100 percent increase.[40]

The NEMS industrial demand module divides each subsector into three components: buildings, boilers-steam-cogeneration, and process and assembly. The *CEF* authors represented the impacts of the programs and

Table 23. Commercial Sector Projections in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
				2010		
Delivered Energy Consumption (Quadrillion Btu)	**7.6**	**9.9**	**9.5**	**9.2**	**9.4**	**9.2**
Electricity	3.7	4.9	4.6	4.4	4.5	4.5
Natural Gas	3.1	4.2	4.1	4.1	4.1	4.0
Petroleum	0.6	0.6	0.6	0.6	0.6	0.6
Delivered Prices (1999 Dollars per Million Btu)	**13.28**	**12.23**	**11.33**	**13.38**	**12.26**	**12.94**
Electricity	21.64	18.76	17.60	21.65	19.70	20.65
Natural Gas	5.34	5.63	5.32	5.73	5.17	5.59
Petroleum	4.99	6.27	6.25	6.17	5.98	6.05
Effective Delivered Prices[a] (1999 Dollars per Million Btu)	**13.28**	**12.23**	**11.33**	**13.38**	**12.65**	**13.32**
Electricity	21.64	18.76	17.60	21.65	19.70	20.65
Natural Gas	5.34	5.63	5.32	5.73	5.89	6.31
Petroleum	4.99	6.27	6.25	6.17	6.96	7.02
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**242**	**315**	**298**	**236**	**261**	**238**
				2020		
Delivered Energy Consumption (Quadrillion Btu)	**7.6**	**10.9**	**10.0**	**9.8**	**9.7**	**9.6**
Electricity	3.7	5.6	4.9	4.6	4.7	4.7
Natural Gas	3.1	4.5	4.4	4.4	4.3	4.3
Petroleum	0.6	0.6	0.6	0.6	0.6	0.6
Delivered Prices (1999 Dollars per Million Btu)	**13.28**	**12.55**	**11.66**	**13.28**	**12.43**	**12.62**
Electricity	21.64	18.83	18.41	21.94	20.22	20.31
Natural Gas	5.34	5.67	5.08	5.42	4.95	5.22
Petroleum	4.99	6.37	6.29	6.16	6.15	6.16
Effective Delivered Prices[a] (1999 Dollars per Million Btu)	**13.28**	**12.55**	**11.66**	**13.28**	**12.82**	**13.01**
Electricity	21.64	18.83	18.41	21.94	20.22	20.31
Natural Gas	5.34	5.67	5.08	5.42	5.67	5.94
Petroleum	4.99	6.37	6.29	6.16	7.12	7.13
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**242**	**347**	**316**	**242**	**261**	**240**

[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

[40]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), Appendix B-2, web site www.ornl.gov/ORNL/Energy_Eff/CEF-B2.pdf.

policies by five general types of changes made within the industrial sector:

- Boiler efficiencies were increased over time
- Building energy use was decreased over time
- Retirement rates were increased for existing equipment
- Production flows within specific sectors were modified
- Technology possibility curves (TPCs), which represent the rate of change between current energy intensity and energy intensity in 2020, were adjusted to reflect more rapid efficiency improvements over time.

The *CEF* authors indicated which of the five modifications would result from the policies or programs without specifying the detailed impact of each. These five types of changes are described in more detail below.

CEF Industrial Boiler Efficiencies

Several of the policies outlined in *CEF* were assumed by the *CEF* authors to increase boiler efficiencies over time. The most important of these is the Steam Challenge program. This voluntary program is a public-private initiative launched in April 1998 to provide targeted information and technical assistance to help industrial customers retrofit, maintain, and operate their steam systems more efficiently and profitably. State industrial energy efficiency programs and clean air partnerships and increased research and development programs were also expected to increase boiler efficiencies. Table 24 shows the assumed improvement in boiler efficiencies across all industries for the *CEF* moderate and advanced cases resulting from these expanded programs. The same boiler efficiency improvements are implemented in the *CEF-JL* cases. Since average boiler efficiency has changed very little over time, these targets may be overly optimistic.[41]

CEF Industrial Buildings Energy Use

Expansion of voluntary programs, such as ENERGY STAR Buildings and Green Lights programs, and industrial sector agreements were identified in *CEF* as means for improving the efficiency of buildings energy use. Investment enabling programs, including expanded State industrial energy efficiency programs, expanded ESCO / Utility programs, and tax incentives for plant energy managers, were also expected by the *CEF* authors to improve the efficiency of building energy use. Many States currently have industrial energy efficiency programs and ESCO / Utility programs, but many of the latter programs have experienced reduced funding lately. Providing tax incentives for energy managers would be a new program. The individual effect of each program was not identified, but the aggregate improvements in the industrial buildings end uses were modified in *CEF* as shown in Table 25.

These energy efficiency improvements, which are also implemented for the *CEF-JL* cases, were applied equally across all industries. These improvements parallel the assumed increase in commercial buildings efficiency in

Table 24. *CEF* Assumptions for Boiler Efficiencies

Category	Baseline Efficiency (Percent)	*CEF* Moderate (Average Percent Increase per Year)[a]	*CEF* Advanced (Average Percent Increase per Year)[a]	Comment
Petroleum	82	0.2	0.2	Included in *CEF-JL*
Natural Gas	80	0.2	0.3	Included in *CEF-JL*
Coal	81	0.2	0.3	Included in *CEF-JL*
Biomass	74	0.1	0.2	Included in *CEF-JL*

[a]Relative to the reference case.
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table 25. *CEF* Assumptions for Buildings Efficiencies

Category	*CEF* Moderate (Annual Improvement Factor)[a]	*CEF* Advanced (Annual Improvement Factor)[a]	Comment
Lighting: Electricity	0.9870	0.9864	Included in *CEF-JL*
Heating, Ventilation, Air Conditioning: Electricity	0.9950	0.9837	Included in *CEF-JL*
Heating, Ventilation, Air Conditioning: Natural Gas	0.9850	0.9850	Included in *CEF-JL*
Heating, Ventilation, Air Conditioning: Steam	0.9975	0.9889	Included in *CEF-JL*

[a]Relative to the reference case.
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

[41]Energy Information Administration, *NEMS Industrial Model: Modeling Energy Efficiency Standards for Boilers and Motors* (Arthur D. Little, Inc., April 1995), and web site www.oit.doe.gov / factsheets / steam_challenge / pdfs / boiler.pdf.

CEF. Because the buildings component in the industrial model covers office areas in the manufacturing sector, not the manufacturing floor, this is a reasonable assumption.

CEF Industrial Equipment Retirement Rates

Similar to boiler efficiency and buildings energy use improvements, many different programs were assumed by the *CEF* authors to contribute to the acceleration of retirement rates. Expanded voluntary industrial sector agreements, an expanded Motor Challenge program, expanded State industrial energy efficiency programs and Clean Air Partnerships, motor standards and certification, and expanded demonstration programs were all mentioned as accelerating the retirement rates for industrial equipment. The retirement rates, which were the same for both the moderate and advanced cases, are shown in Table 26, along with those included in the reference case. The *CEF* retirement rates are used in the *CEF-JL* cases.

CEF Industrial Production Flow Modifications

In the *CEF* study, production flows for two industries, paper and cement, were modified to reflect the impact of consumer information programs which encourage demand for environmentally benign products. In the paper industry, this program would take the form of labeling recycled / nonbleached paper. As a result of this labeling program, the share of waste pulping was projected to increase by 0.2 percent per year in the *CEF* moderate case and by 0.4 percent per year in the *CEF* advanced case. In the advanced case, the recycled share of pulping input increased to 46 percent, which is not an unreasonable assumption. In order to maintain a reasonable balance of production flows, kraft pulping was projected to decrease by 0.2 percent per year in the *CEF* moderate case and by 0.4 percent per year in the *CEF* advanced case. Bleaching throughput was assumed to decrease by 0.1 percent per year in the *CEF* moderate case and by 0.2 percent in the *CEF* advanced case. The same modifications to production flows in the paper industry are incorporated in the *CEF-JL* cases.

In the cement industry, the *CEF* authors proposed a program promoting the establishment of performance-based cement standards. This program would disseminate information to public and private agencies responsible for cement procurement and specification on the environmental advantages of blended cements. While the use of blended cements may be practical, such a change must be approved by the American Society for Testing and Materials. The *CEF* moderate case assumed that the increased use of blended cements would reduce the use of clinker, which is the raw material used to produce cement, by 6.9 million tons, and the *CEF* advanced case assumed it would reduce the use of clinker by 16.4 million tons. The increased use of blended cements would lead to lower process emissions of CO_2. These process emissions are not modeled in NEMS.

In the steel industry, *CEF* assumed that electric arc furnaces (EAF) would increase their share of production from 40 percent to 55 percent in the advanced case, while the share for basic oxygen furnaces (BOF) would decrease. Since the reference case projects that EAF will attain a 55-percent share in 2020, no changes are made for the *CEF-JL* advanced case. In the *CEF* study, there was no change in steel industry production flows in the moderate case. The EAF is much less energy intensive than the BOF. However, at this time, the EAF plants are not expected to be able to produce the full range of steel products, which limits their applicability.

Table 26. Reference Case and *CEF* Assumptions for Equipment Retirement Rates
(Percent)

Industry	Reference Case	*CEF* Moderate and Advanced Cases	Comment
Agriculture	1.0	2.5	Included in *CEF-JL*
Mining	1.0	2.5	Included in *CEF-JL*
Construction	1.0	2.5	Included in *CEF-JL*
Food	1.7	2.1	Included in *CEF-JL*
Paper	2.3	2.3	Included in *CEF-JL*
Bulk Chemicals	1.7	2.5	Included in *CEF-JL*
Glass	1.3	1.4	Included in *CEF-JL*
Cement	1.2	2.0	Included in *CEF-JL*
Steel: Blast Furnace/Basic Oxygen Furnace	1.0	1.5	Included in *CEF-JL*
Steel: Electric Arc Furnace	1.5	1.8	Included in *CEF-JL*
Steel: Coke Ovens	1.5	1.8	Included in *CEF-JL*
Steel: Other	2.9	2.9	Included in *CEF-JL*
Aluminum	2.1	2.3	Included in *CEF-JL*
Metal-Based Durables	1.5	1.9	Included in *CEF-JL*
Other Manufacturing	2.3	2.5	Included in *CEF-JL*

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

In the industrial model, some industries produce biomass as a byproduct of the production process, notably the pulp and paper industry. The *CEF* analysis assumed more aggressive recovery of biomass byproduct. The reference case assumes that biomass byproduct recovery will increase by 0.2 percent per year. In the advanced technology case, byproduct recovery is assumed to increase by 1.0 percent per year. For the *CEF-JL* moderate case, the reference case assumption is used, while the *CEF-JL* advanced case uses the advanced technology assumption.

CEF Industrial Technology Possibility Curve Modifications

Within the industrial demand model, the rate of change between the current energy intensity and energy intensity in 2020 is defined as the technology possibility curve (TPC) with values interpolated for the intervening years. In most cases, the TPCs are negative in the reference case, indicating that energy intensity is projected to decrease over time.

Almost all the industrial sector policies included in *CEF* were expected to have an impact on the TPCs. However, the effects of the individual policies on the TPCs were not specified. Instead, the overall changes were provided in the *CEF* documentation. In most situations, the changes made in *CEF* were relative to the parameter values used in *AEO99*. For the *CEF-JL* cases, similar changes are incorporated in the current version of NEMS by applying these relative changes to the current parameter values. It is possible that the *CEF* modifications may not be additive to the decline rates in the reference case TPCs, which are generally more rapid than those assumed in *AEO99*, but in the absence of more detailed information it is not possible to determine the extent to which this is the case.

The industrial sector technology changes in *CEF* for the pulp and paper, cement, and steel industries were based on detailed analysis of sector-specific technologies. For the remaining industrial subsectors, the technology changes assumed by the *CEF* authors were based on general trends in energy intensity improvements. In addition, some technology or efficiency improvements that cut across subsectors were implemented by the *CEF* authors.

To represent the combined effect of all the policies in the *CEF* study, the TPCs for the nonintensive industries (agriculture, mining, construction, metal-based durables, and other manufacturing) were multiplied by 1.5 for the moderate case and by 2.0 for the advanced case. For the *CEF-JL* cases, the same modifications are included, with the factors applied to the reference case TPCs. These changes are consistent with the changes implemented in the advanced technology case.

In the *CEF* study, the TPCs for the food and glass industries in the advanced case were set to the values assumed in the *AEO99* high technology case. For the moderate case, the TPCs were set at the midpoint between the *AEO99* reference case and high technology values. For the *CEF-JL* cases, the TPCs for the food and glass industries are modified using the same methodology and the reference and advanced technology case TPCs.

The TPC values for the paper, bulk chemicals, cement, steel, and aluminum industries are taken directly from the *CEF* Appendix A-2. There was no uniform modification of the TPCs for these energy-intensive sectors in the *CEF* analysis. Instead, unit energy consumptions (UECs) were chosen based on external sources to represent specific processes and equipment. The TPCs were then calculated based on the 1994 and 2020 UECs.

Appendix B presents the TPCs used in the *CEF-JL* cases. It should be noted that the exact values of the TPCs generally do not match those published in Appendix A-2 of the *CEF* report because the *CEF*-derived TPCs usually were based on the methodology applied in the *CEF* analysis to the *AEO99* model parameters.

In some instances, the NEMS industrial model could not be modified to incorporate assumptions included in the *CEF* analysis. Most notably, in the pulp and paper industry, integrated black liquor or biomass gasifiers were not included in the moderate or advanced cases. The *CEF* analysis did not address cogeneration within NEMS although there was a discussion of a separate cogeneration analysis. Therefore, for the *CEF-JL* analysis, no cogeneration assumptions are modified in the industrial model.

Impact of *CEF* Policies on Industrial Demand

In the *CEF-JL* moderate case, delivered industrial energy consumption is projected to be 2 percent, or 0.8 quadrillion Btu, lower in 2010 and 4 percent, or 1.6 quadrillion Btu, lower in 2020 than in the reference case (Table 27). Projected consumption of all energy sources is lower in the moderate case, with petroleum products declining the most in 2010 and in 2020.The *CEF-JL* moderate case results in a larger decrease in projected energy consumption than the advanced technology case, even though the advanced technology TPCs generally decline more rapidly. The larger projected energy savings in the *CEF-JL* moderate case are due to the boiler and building efficiency improvements which are not assumed in the advanced technology case. CO_2 emissions in the industrial sector are projected to be reduced by 11 and 19 million metric tons carbon equivalent, or 2 and 3 percent, in 2010 and 2020, compared to reference case levels.

The *CEF-JL* advanced case assumes higher availability of renewables in the paper industry. Total renewable energy consumption in the industrial sector is projected to be higher by 5 percent, or 0.1 quadrillion Btu, in 2010 and by 12 percent, or 0.4 quadrillion Btu, in 2020 as compared with the reference case. Consumption of all other energy sources is projected to be lower in both 2010 and 2020 in the *CEF-JL* advanced case. Partly due to the $50 carbon fee, projected delivered industrial energy consumption is reduced by 5 and 8 percent in 2010 and 2020, respectively, relative to the reference case, and projected CO_2 emissions are reduced by 60 and 96 million metric tons carbon equivalent, or 11 and 16 percent.

Table 27. Industrial Sector Projections in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
		2010				
Industrial Output (Billion 1992 Dollars)	**4,722**	**6,223**	**6,215**	**6,214**	**6,205**	**6,203**
Industrial Output Growth (Annual Percent, 1999-2010)	**—**	**2.54**	**2.53**	**2.53**	**2.51**	**2.51**
Delivered Energy Consumption (Quadrillion Btu)	**27.6**	**31.1**	**30.4**	**30.4**	**29.7**	**29.6**
Petroleum	9.5	10.5	10.2	10.2	9.9	10.0
Natural Gas	9.8	11.3	11.0	11.2	10.7	10.7
Coal	2.5	2.6	2.5	2.5	2.4	2.3
Renewables	2.2	2.6	2.6	2.6	2.8	2.8
Purchased Electricity	3.6	4.2	4.1	3.9	3.9	3.9
Delivered Energy Intensity (Thousand Btu per 1992 Dollar of Output)	**5.84**	**5.00**	**4.89**	**4.89**	**4.78**	**4.78**
Change in Delivered Energy Intensity (Annual Percent, 1999-2010)	**—**	**-1.39**	**-1.60**	**-1.59**	**-1.79**	**-1.80**
Average Delivered Prices (1999 Dollars per Million Btu)	**5.29**	**5.62**	**5.33**	**5.99**	**5.44**	**5.79**
Electricity	13.12	12.04	11.15	15.09	13.18	14.01
Natural Gas	2.79	3.46	3.12	3.56	2.96	3.42
Petroleum	5.54	6.07	6.01	5.92	5.60	5.75
Effective Delivered Prices[a] (1999 Dollars per Million Btu)	**5.29**	**5.62**	**5.33**	**5.99**	**6.03**	**6.39**
Electricity	13.12	12.04	11.15	15.09	13.18	14.01
Natural Gas	2.79	3.46	3.12	3.56	3.67	4.12
Petroleum	5.54	6.07	6.01	5.92	6.19	6.34
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**480**	**533**	**522**	**468**	**473**	**454**
		2020				
Industrial Output (Billion 1992 Dollars)	**4,722**	**8,083**	**8,062**	**8,060**	**8,042**	**8,043**
Industrial Output Growth (Annual Percent, 1999-2020)	**—**	**2.59**	**2.58**	**2.58**	**2.57**	**2.57**
Delivered Energy Consumption (Quadrillion Btu)	**27.6**	**34.7**	**33.2**	**33.2**	**32.0**	**32.0**
Petroleum	9.5	11.6	10.9	11.0	10.5	10.5
Natural Gas	9.8	12.7	12.2	12.7	11.6	11.6
Coal	2.5	2.6	2.5	2.5	2.3	2.3
Renewables	2.2	3.1	3.0	3.0	3.4	3.4
Purchased Electricity	3.6	4.8	4.5	4.0	4.2	4.2
Delivered Energy Intensity (Thousand Btu per 1992 Dollar of Output)	**5.84**	**4.30**	**4.11**	**4.12**	**3.98**	**3.98**
Change in Delivered Energy Intensity (Annual Percent, 1999-2020)	**—**	**-1.45**	**-1.65**	**-1.64**	**-1.81**	**-1.81**
Average Delivered Prices (1999 Dollars per Million Btu)	**5.29**	**5.82**	**5.47**	**5.96**	**5.58**	**5.73**
Electricity	13.12	12.07	11.77	15.57	13.63	13.71
Natural Gas	2.79	3.73	3.11	3.46	2.99	3.26
Petroleum	5.54	6.12	6.01	5.90	5.64	5.71
Effective Delivered Prices[a] (1999 Dollars per Million Btu)	**5.29**	**5.82**	**5.47**	**5.96**	**6.16**	**6.31**
Electricity	13.12	12.07	11.77	15.57	13.63	13.71
Natural Gas	2.79	3.73	3.11	3.46	3.70	3.97
Petroleum	5.54	6.12	6.01	5.90	6.22	6.28
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**480**	**585**	**566**	**494**	**489**	**472**

[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Impact of Emissions Limits on Industrial Demand in the *CEF-JL* Cases

The emissions limits on the electricity generation sector have a similar effect on industrial sector energy demand in the *CEF-JL* cases as in the advanced technology case. In both the *CEF-JL* moderate and advanced cases with emissions limits, total projected delivered energy consumption is essentially unchanged from the same cases without the limits.

Applying the emissions limits in the *CEF-JL* moderate case is projected to raise the industrial electricity price by 35 and 32 percent in 2010 and 2020, respectively, while effective natural gas prices are projected to increase by 14 and 11 percent. As a result, purchased electricity is projected to be reduced by 5 percent in 2010 and by 11 percent in 2020. Compared to the case without emissions limits, projected natural gas consumption in the *CEF-JL* moderate case with limits is higher by 2 percent in 2010 and 4 percent in 2020, accounting for the slight increase in total consumption. Cogeneration using natural gas is projected to be 50 percent higher in 2010 than in the case without emissions limits and 102 percent higher in 2020.

In the *CEF-JL* advanced case, which includes a carbon fee of $50 per metric ton carbon equivalent, the difference in projected delivered industrial energy consumption between the two cases with and without emissions limits is negligible. In 2010, projected electricity and effective natural gas prices both increase in the case with emissions limits, 6 percent and 12 percent, respectively, compared to the case without the limits. In 2020, effective natural gas prices are projected to be higher by 7 percent and electricity prices are slightly higher. Overall, the imposition of the emissions limits is projected to cause very little change in fuel mix in the *CEF-JL* advanced case.

In the *CEF-JL* moderate case with emissions limits, CO_2 emissions in the industrial sector are projected to be lower by 54 and 72 million metric tons carbon equivalent (10 and 13 percent) in 2010 and 2020, respectively, compared to the case without limits. In the *CEF-JL* advanced case, projected CO_2 emissions are reduced by 19 million and 17 million metric tons carbon equivalent (4 and 3 percent) in 2010 and 2020, respectively. In all instances, the reductions are largely due to the use of electricity in the industrial sector, either through lower projected electricity demand or a change in the composition of the fuels used to generate electricity.

Transportation

Transportation sector technology and policy assumptions in the *CEF* study reflected reductions in component costs as well as efficiency improvements necessary for the economic viability and market adoption and penetration of advanced vehicle technologies. The assumptions in the *CEF* analysis reflected a very high level of optimism. The authors of *CEF* assumed dramatic increases in funding for vehicle-related research and development and a high level of optimism that this research and development will prove successful in meeting all advanced technology efficiency and cost goals. The same increased funding also led to the successful early market introduction of low-cost high efficiency technologies, a similarly optimistic outcome.

Efficiency improvements achieved market success through the adoption and implementation of a mixture of low-cost advanced technologies, new policies, and assumed changes in manufacturer and consumer market behavior. The *CEF* authors assumed that a shift in the light vehicle market would occur, increasing the demand for high efficiency vehicles. This shift in demand was implemented through an increase in payback period from four to twelve years, while discount rates were increased from 8 to 15 percent. Other policies complemented research and development by stimulating demand for new technologies and promoting efficient system operation.

For the transportation sector, the input assumptions and modifications to model algorithms in the *CEF* analysis are replicated in the *CEF-JL* cases where applicable. In some instances, the model structure in the *AEO2001* version of the model has been modified to the extent that the changes indicated in the *CEF* report are no longer applicable, as discussed below. In addition, more current information is available for technology cost and potential efficiency improvements and, as a result, there are a few instances where assumptions regarding advanced technologies in the reference case are more optimistic than those in the *CEF* analysis.

Light-Duty Vehicles

Improvements in the efficiency of light-duty vehicles occurred as the result of technology cost reductions achieved by increased government and industry research and development spending, combined with tax credits. In *CEF*, the authors assumed that government and industry research and development spending would be increased 50 percent over 1999 levels in the moderate case and 100 percent in the advanced case. In both cases, spending increases were ramped up within a five-year period. No assumptions associated with advanced technologies were changed prior to year 2003 because it was assumed that funding increases would not see appreciable results before this time. It is important to note that, although the assumptions made in the *CEF* analysis are implemented in this study, the required increases in research and development spending have not occurred. As a result, the implementation of these assumptions reflects a level of optimism that exceeds the underlying assumptions.

Tax Credit for High-Efficiency Vehicles

CEF included a tax credit that reduced the cost of hybrid electric and fuel cell vehicles by $1,000 to $5,000 depending on the level of efficiency improvement, and the cost reduction was phased out after vehicle production reached 50,000 units per year. Hybrid electric vehicles maintained a continuous $1,000 reduction throughout the projection period. This policy was designed to stimulate the demand for electric drivetrain light vehicles by providing a tax credit. Currently, there are similar State-administered policies of this type in effect. Although these policies have not shown significant success to date, they are expected to have greater impact on the market as product offerings increase. It also important to note that tax credits for the most efficient fuel cell vehicles alone would reach $250 million per year before being phased out. This policy is implemented in the *CEF-JL* cases using the same assumptions as the *CEF* analysis.

Invigorated Government Fleet Programs

The *CEF* analysis contended that, if Federal and State fleet vehicle requirements under the Energy Policy Act of 1992 were met, then alternative fuel availability would increase as a result. This, in turn, would provide greater consumer acceptance of alternative-fuel vehicles, thus increasing their market penetration. Fuels specifically impacted by this assumption included ethanol and hydrogen with availability increasing to at least 50 percent by 2020. As stated in the *CEF* report, the *AEO99* projections estimated that some regions of the country would have ethanol fuel availability exceeding 50 percent in 2020. For the *CEF-JL* cases, fuel availability for ethanol and hydrogen reaches a minimum of 50 percent in each Census region, as assumed in the *CEF* study.

Increases in Research and Development Spending

This policy, which was described above, resulted in earlier market introduction dates as well as decreased incremental costs and improved efficiency of advanced technologies and reflected a high level of optimism as discussed above. Conventional and advanced vehicle technologies were impacted in the following ways:

- The introduction dates for conventional technologies were accelerated by 30 percent in the moderate case and 40 percent in the advanced case.
- Two new lightweight materials technologies were added.
- The efficiency of hybrid electric and fuel cell technologies were incrementally increased and the cost incrementally decreased.

For this analysis, the introduction dates, efficiency improvements, and the availability of new conventional technologies reflect the *CEF* assumptions. With respect to *CEF* assumptions regarding hybrid electric and fuel cell vehicles, the vehicle choice algorithms have been updated in the *AEO2001* version of NEMS to reflect a more logical costing structure for these technologies. As a result, some of the fuel cell assumptions in the *CEF* study are not implemented. These include replacing the incremental cost equations with a single equation representing fuel cell costs and implementing an exponential fuel cell cost equation that incorporates a rate of decline that is itself declining exponentially. Assumptions regarding fuel cell cost representing kilowatts required per ton of vehicle weight, stack cost, motor cost, and reformer cost are modified to reflect the *CEF* values.

Cellulosic Ethanol Commercialization

The *AEO99* reference case and the *CEF* business-as-usual case assumed that the production cost of biomass (cellulosic) ethanol would decline 20 percent by 2020 and that 250 million gallons of annual capacity would be added annually. The *CEF* moderate and advanced cases assumed that loan guarantees, tax incentives, or subsidies would reduce or eliminate the added risk of investment in new biomass ethanol capacity. The production cost was assumed to decline 50 percent by 2020, and the annual rate of capacity expansion was assumed to be 650 million gallons starting in 2006.

The reduction in production costs for biomass ethanol was similar to those in a recent EIA study, which assumed a 33-percent reduction by 2015 in the reference case and a 66-percent reduction in a high technology case.[42] However, the rates of capacity expansion assumed in the *CEF* moderate and advanced cases were quite high. The biomass ethanol industry was projected to have 9.8 billion annual gallons of capacity by 2020, but output of 7.0 billion gallons and 7.3 billion gallons in the moderate and advanced cases, respectively. This implied capacity utilization of 74 percent in the advanced case, which is very low for the refining industry, where capacity utilization rates generally average more than 90 percent.

Vehicle Choice Model Modifications

The vehicle choice model used for the *CEF* analysis incorporated extensive changes to the *AEO99* version of NEMS. One significant change to the methodology greatly increased the penetration of alternative-fuel and

[42]Energy Information Administration, *Outlook for Biomass Ethanol and Production and Demand* (Washington, DC, April 2000), web site www.eia.doe.gov/oiaf/analysispaper/biomass.html.

advanced technology vehicles. However, this methodology is no longer used in the *AEO2001* version of NEMS for market penetration estimation.

In addition, vehicle choice model coefficients were modified in *CEF*-NEMS to provide greater price elasticity than represented in the *AEO99* version of NEMS. Since the *CEF* study was completed, the NEMS vehicle choice model has been modified to incorporate a new nesting structure and new vehicle attribute coefficients that also provide greater price elasticity. As a result, the changes reflected in the *CEF* analysis do not apply.

Vehicle Miles Traveled Reduction Programs

In the *CEF* report, it was stated that the annual growth rate of 1.6 percent in vehicle miles traveled projected in the *AEO99* reference case from 1997 to 2020 was very low and that these growth rates would be unlikely without the successful implementation of travel reduction programs. The *CEF* authors noted that historical trends reveal an average annual growth rate in vehicle miles traveled of 2.8 percent between 1974 and 1995, further noting that other experts have projected that travel by light-duty vehicles will grow at approximately 2.0 percent per year over the next two decades.

The reference case projects an average annual growth in vehicle miles traveled of 1.9 percent through 2020, which incorporates current policies designed to reduce travel in the future. Although this is closer to the values cited in the *CEF* study as a likely projection, the effective implementation of travel reduction policies is a very difficult task requiring coordinated efforts between State and local governments. As stated in the *CEF* report, this encompasses a great effort with a commitment to changing the travel characteristics of commuters, making this a very difficult set of programs to analyze. As a result, this analysis assumes that the growth rates in vehicle miles traveled projected in the reference case adequately reflect the policies enacted for the *CEF* study.

Intelligent Traffic Control Systems

This program implemented advanced electronic control systems designed to reduce travel times for commuters. In effect, the impact of traffic congestion was reduced, reducing the fuel economy degradation factor by 1 percent over the forecast period. The fuel economy degradation factor represents a decrease in on-road fuel economy from the values reported by the Environmental Protection Agency. Traffic congestion is one of several contributing factors in fuel economy degradation, and as travelers reduce the amount of time in congested driving conditions, on-road fuel economy is increased. This assumption is directly implemented in the *CEF-JL* cases.

Voluntary Agreements

This policy, implemented in the *CEF* advanced case only, assumed that voluntary agreements would be adopted to promote greater vehicle manufacturer attention to fuel economy relative to other vehicle attributes. This policy was implemented by reducing consumer demand for horsepower. For the *CEF-JL* advanced case, modifications for horsepower demand reflect those implemented in the *CEF* study. However, in some cases, the coefficients for horsepower demand used in the reference case are already lower than those used in the *CEF* study, so the associated impacts on fuel economy are not as large.

"Variabilization" Policies

This policy, again implemented in the advanced case only, simulated a pay-at-the-pump insurance surcharge to all motor vehicles. This surcharge reduced the fixed cost of automobile insurance by "variabilizing" a portion of insurance costs to the amount of miles driven per year. In effect, this allowed consumers to lower insurance costs by either driving less or by driving a more efficient vehicle. The *CEF* fuel price increases were implemented to reflect an increase of $0.34 per gallon from 2003 to 2012 and $0.51 per gallon from 2013 to 2020 for all highway fuels. These same assumptions are in the *CEF-JL* advanced case. Although it makes sense that automobile insurance should vary by the amount of vehicle travel, the probability that such a program would be implemented on a national level is very unlikely. Issues surrounding accident risk by region and disbursement of funds to insurance companies would require significant study and development and could take many years implement.

Freight Trucks

In the *CEF* analysis, improvements in heavy truck efficiency were accomplished primarily through increased research and development spending by government and industry. This resulted in the adoption of new technologies not included in the *AEO99* reference case as well as efficiency improvements of selected technologies included in the reference case. Similar to the light-duty vehicle technology assumptions, the *CEF* authors assumed a 50-percent increase in research and development funding in the moderate case and a 100-percent increase in the advanced case.

The technology assumptions for the *CEF* moderate case reflected the adoption of the LE-55 engine, a 55-percent efficient diesel engine, and included improvements to the current advanced technologies. The LE-55 engine was introduced in 2010. This technology was not included in the *AEO99* reference case but is included in the current reference case where it is assumed to begin market penetration in 2009. In the *CEF-JL* moderate case, the maximum market share is set to 100 percent for both medium and heavy trucks and efficiency improvements are adjusted to reflect *CEF* values. Turbo-compounding is deleted and replaced by materials substitution, which reflects an improvement in efficiency realized from a reduction in vehicle empty weight travel. This policy is introduced in 2005. In addition, incremental efficiency improvements for advanced tires and lubricants are increased from 5 percent to 10 percent. The incremental efficiency improvements for electronic transmission controls are set to 5 percent for medium trucks and 3 percent for heavy trucks and for advanced drag reduction are set to 7 percent for medium trucks and 18 percent for heavy trucks. Initial penetration of advanced technologies in the freight truck model is represented using a trigger point methodology. For this study, all technology trigger prices are set below the lowest projected fuel price as in the *CEF* analysis. This assumes that all technologies become cost effective, indicating that research and development successes are critical in achieving marketable advanced technologies.

The *CEF* advanced case included all assumptions made in the moderate case, added hybrid technology in 2005, and advanced the introduction date of the LE-55 technology. The hybrid technology was not included in the *AEO99* reference case but is included for medium trucks in the current reference case. For the *CEF-JL* advanced case, hybrid technology is included for heavy trucks as well, assuming a maximum market penetration of 25 percent for diesel heavy trucks and 100 percent for all other gasoline trucks. The fuel efficiency benefit is 25 percent for diesel trucks and 45 percent for gasoline trucks. The LE-55 technology introduction date is advanced to 2005 and medium truck efficiency improvement is increased. As stated above, the ability to meet these technology goals hinges on the assumption that significant investment is made in research and development and that the investment is successful. Without these significant increases in funding, there is little chance that these technologies will meet the stated cost and efficiency goals.

Air

CEF policies and increased research and development spending were assumed to achieve a 5-percent reduction in air traffic fuel use and were incorporated by increasing the rate of efficiency improvement, from 0.18 percent to 0.34 percent for wide-body aircraft and from 0.44 percent to 0.60 percent for narrow-body aircraft. This improvement reflected a combination of technology adoption and increased load factors. The *CEF* study added one new technology, blended wing body aircraft, and assumed the values in NEMS for efficiency improvements and costs for existing technologies.

No detail was provided in *CEF* on the efficiency or cost of the blended wing body technology. The *CEF* study indicated that load factors were increased from 72 percent to 73 percent for international travel and made no explicit statement regarding domestic load factors other than to state that current domestic load factors were higher than the values projected in *AEO99*.

Efficiency improvements in the *CEF* moderate and advanced cases were intended to reflect "general improvement in aircraft operating efficiency due to more effective flight planning and reductions in excessive time spent waiting in the air or waiting on the ground due to traffic congestion." Although it is true that reducing aircraft taxi time will reduce fuel use, much of the traffic congestion expected to occur in the future will be due to limited infrastructure. More effective flight planning would certainly increase efficiency, but without airport expansion there will be limits to the amount of efficiency realized. NEMS does not address airport operation efficiency and therefore such improvements are reflected via improved aircraft efficiency and / or increased load factors. The *CEF* study assumed aggressive growth in aircraft efficiency, which was implemented through adjustments in the trigger price, and moderate increases in load factors. The *CEF-JL* cases reflect the values achieved in *CEF*.

Rail

The *CEF* study assumed that fuel cell propulsion, advanced electric motors, advanced diesel engines, rail lubrication systems, and information control systems would be implemented to improve rail efficiency. In the moderate case, rail efficiency increased to 3.5 ton-miles per thousand Btu by 2020, 13 percent higher than in the reference case. In addition, it was assumed that 2 percent of freight truck ton-miles would be shifted to rail. The report indicated that this increased rail travel 33 billion ton-miles by 2020, but no reduction in truck vehicle miles traveled was provided. In the advanced *CEF* case, rail efficiency increased to 3.9 ton-miles per thousand Btu by 2020, 26 percent higher than in the reference case. It was assumed that 5 percent of freight truck ton-miles would be shifted to rail, increasing rail travel 83 billion ton-miles by 2020. For the *CEF-JL* cases, the efficiency improvements are implemented but not the shift in travel from truck to rail. Although rail travel is measured in ton-miles traveled, truck freight travel is measured in vehicle miles traveled. No explanation was offered in *CEF* regarding the conversion of truck vehicle miles traveled to rail ton-miles traveled, making it impossible to determine the overall effect on freight travel from a shift to rail travel.

Marine

The *CEF* study assumed that marine vessel efficiency would improve to 2.86 ton-miles per thousand Btu in the moderate case and 2.95 ton-miles per thousand Btu in the advanced case by 2020, 6 percent and 9 percent higher, respectively, than in the reference case. This assumed the adoption of fuel cell technology and the implementation of improved maintenance and operations programs. The reference case assumes that marine vessel efficiency increases to 2.99 ton-miles per thousand Btu by 2020, as updated to reflect more recent historical trends, so no additional changes are made in the *CEF-JL* cases.

Impact of *CEF* Policies on Transportation Demand

For the transportation sector, the *CEF* study assumed significant increases in research and development along with fundamental shifts in the demand for efficiency across all modes. The assumptions for incremental technology cost and efficiency improvement reflected a greater level of optimism and success for advanced technologies than in the reference case. The *CEF* assumptions or modifications are incorporated in the *CEF-JL* cases to the extent feasible, although there are instances where they no longer apply to the current model as noted above.

In the *CEF-JL* moderate case, new light-duty vehicle fuel efficiency is projected to increase to 28.0 miles per gallon in 2010 and 29.0 miles per gallon in 2020, representing a 3-percent increase over the reference case in both years (Table 28) Heavy truck efficiency is projected to increase to 6.8 miles per gallon in 2010 and 7.4 miles per gallon in 2020, increases of 6 and 7 percent over the reference case in those two years, respectively. In 2010, the other modes are expected to show little change between the reference case efficiency values and those projected in the *CEF-JL* moderate case. In 2020, projected air efficiency increases 4 percent above the reference case and rail and marine efficiencies show little change. Total transportation energy use is expected to be lower by 2 percent, or 0.7 quadrillion Btu, in 2010 and 5 percent, or 1.8 quadrillion Btu, in 2020 (Table 29). Projected transportation CO_2 emissions are lower by 14 and 46 million metric tons carbon equivalent, or 2 and 6 percent, in 2010 and 2020, respectively.

In the *CEF-JL* advanced case which includes a $50 carbon fee, new light-duty vehicle fuel efficiency is projected to increase to 31.6 miles per gallon in 2010 and 34.4 miles per gallon in 2020. These efficiencies represent increases of 16 percent in 2010 and 22 percent in 2020 relative to the reference case. The projected efficiency of heavy trucks shows no significant increase over the moderate case in 2010 but increases to 7.6 miles per gallon in 2020, an improvement of 10 percent over the reference case. For 2010, the air and rail modes are expected to have efficiency improvements of 2 and 6 percent, respectively, over the reference case, with the efficiencies in 2020 improving to 8 and 15 percent over the reference case for the two modes, respectively.

Significant travel reductions are projected for light-duty vehicle and rail travel in the *CEF-JL* advanced case. Highway fuel costs are expected to increase for light-duty vehicles, as a result of pay-at-the-pump insurance and the carbon fee, reducing the projected demand for light-duty vehicle travel by 8 percent in 2010 and 7 percent in 2020. The reduction in projected rail travel comes primarily from reduced coal shipments, lowering rail travel by 10 and 14 percent in 2010 and 2020, relative to the reference case. In 2010, total projected delivered transportation energy use is reduced by 11 percent, or 3.6 quadrillion Btu, and by 18 percent, or 6.7 quadrillion Btu, in 2020. Projected transportation CO_2 emissions are reduced by 69 and 137 million metric tons carbon equivalent, or 11 and 19 percent, in 2010 and 2020, respectively.

In 2020, there is a slight increase in the projected use of ethanol in the *CEF-JL* moderate case. Cellulose ethanol production is projected to reach 516 thousand barrels per day by 2020, higher than the 456 thousand barrels per day in the *CEF* study, mainly due to the lack of any State limits on methyl tertiary butyl ether (MTBE) in *CEF*.[43] The ban in California alone is expected to add 40 thousand barrels per day to ethanol consumption. In the *CEF-JL* advanced case, cellulose ethanol production is projected to reach 412 thousand barrels per day in 2020. E85 consumption is similar in both cases; however, in the *CEF-JL* moderate case, 513 thousand barrels per day of ethanol is projected to be blended into gasoline in 2020, and in the *CEF-JL* advanced case only 372 thousand barrels per day of ethanol is projected to be blended into gasoline. Projected ethanol demand is lower in the *CEF-JL* advanced case than in the *CEF-JL* moderate case due to lower gasoline demand. In 2020, the projected price of ethanol in the reference case is $48.13 per barrel, declining to $32.55 per barrel in the *CEF-JL* moderate case, largely due to the ethanol commercialization program, and to $29.80 per barrel in the *CEF-JL* advanced case, as a result of the lower demand.

Impact of Emissions Limits on Transportation Demand in the *CEF-JL* Cases

In both the moderate and advanced *CEF-JL* cases, the emissions limits on electricity generators have no

[43]MTBE is a widely used gasoline blending component, initially added as an octane enhancer and now used to meet oxygen requirements in reformulated gasoline. There are now concerns about MTBE contamination of water supplies.

significant impact on efficiency improvements. The only significant impact on travel is a reduction in rail travel due to lower shipments of coal. Fuel consumption by rail is slightly lower and by pipelines is slightly higher than in the cases without the emissions limits. As a result, no significant change is projected for total transportation energy consumption or CO_2 emissions as a result of the emissions limits.

Electricity and Renewables

The *CEF* study analyzed policies that would bring about a reduction in CO_2 emissions from electricity generators through three mechanisms: increasing the efficiency of individual fossil-fired power plants, reducing or sequestering the emissions from these plants, and fuel switching, including increased use of renewable sources of generation. The policies focused on enhanced research and development that was assumed to bring about additional technology advances and reduced costs, along with tax credits to encourage the use of renewable generation. The analysis also assumed full competition in the electricity generation sector. The following sections discuss the *CEF* policies and how they were incorporated in the *CEF-JL* cases.

Enhanced Research and Development: Fossil

In the *CEF* study, increases in research and development were assumed to result in improvements in the performance of new technologies and lower capital costs. For the moderate case in *CEF*, the technology characteristics were the same as the assumptions from the *AEO99* high fossil case, which assumed approximately a 15-percent

Table 28. Transportation Efficiency and Travel in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
				2010		
Energy Efficiency Indicators						
New Light-Duty Vehicle (Miles per Gallon)	24.2	27.2	28.0	28.1	31.6	31.6
New Car (Miles per Gallon)	27.9	32.5	34.5	34.5	38.0	38.0
New Light Truck (Miles per Gallon)	20.8	23.3	23.5	23.5	26.9	26.9
Light-Duty Fleet (Miles per Gallon)	20.5	21.0	21.2	21.3	22.8	22.8
Aircraft Efficiency (Seat Miles per Gallon)	51.7	56.1	56.2	56.2	57.5	57.5
Freight Truck Efficiency (Miles per Gallon)	6.0	6.4	6.8	6.8	6.8	6.8
Rail Efficiency (Ton Miles per Thousand Btu)	2.8	3.1	3.1	3.1	3.3	3.3
Domestic Shipping (Ton Miles per Thousand Btu)	2.3	2.7	2.7	2.7	2.7	2.7
Travel						
Light-Duty Vehicle (Billion Miles)	2,394	3,059	3,061	3,060	2,816	2,816
Heavy-Duty Vehicle (Billion Miles)	204	279	275	275	275	275
Air (Billion Seat Miles)	1,099	1,586	1,594	1,594	1,588	1,586
Rail (Billion Ton Miles)	1,353	1,708	1,680	1,453	1,545	1,462
Domestic Shipping (Billion Ton Miles)	661	778	754	748	739	738
				2020		
Energy Efficiency Indicators						
New Light-Duty Vehicle (Miles per Gallon)	24.2	28.1	29.0	29.0	34.4	34.4
New Car (Miles per Gallon)	27.9	32.5	34.5	34.5	40.1	40.1
New Light Truck (Miles per Gallon)	20.8	24.7	25.0	25.0	30.0	30.0
Light-Duty Fleet (Miles per Gallon)	20.5	21.5	22.1	22.1	25.8	25.8
Aircraft Efficiency (Seat Miles per Gallon)	51.7	60.3	62.5	62.3	65.4	65.4
Freight Truck Efficiency (Miles per Gallon)	6.0	6.9	7.4	7.4	7.6	7.6
Rail Efficiency (Ton Miles per Thousand Btu)	2.8	3.4	3.5	3.5	3.9	3.9
Domestic Shipping (Ton Miles per Thousand Btu)	2.3	3.0	3.0	3.0	3.0	3.0
Travel						
Light-Duty Vehicle (Billion Miles)	2,394	3,575	3,579	3,579	3,315	3,316
Heavy-Duty Vehicle (Billion Miles)	204	352	339	338	337	337
Air (Billion Seat Miles)	1,099	2,316	2,340	2,340	2,332	2,332
Rail (Billion Ton Miles)	1,353	1,967	1,881	1,609	1,693	1,594
Domestic Shipping (Billion Ton Miles)	661	890	826	812	795	796

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Table 29. Transportation Energy Consumption in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
		2010				
Energy Use by Mode (Quadrillion Btu)						
Light-Duty Vehicle	15.5	19.2	18.9	18.9	16.2	16.2
Heavy-Duty Vehicle	4.6	5.8	5.4	5.4	5.4	5.4
Air	3.5	4.6	4.6	4.6	4.5	4.5
Rail	0.6	0.7	0.6	0.6	0.6	0.5
Marine	1.3	1.5	1.5	1.5	1.4	1.4
Pipeline Fuel	0.7	0.9	0.9	1.0	0.9	0.9
Lubricants	0.2	0.3	0.3	0.3	0.3	0.3
Total	**26.3**	**32.8**	**32.0**	**32.1**	**29.2**	**29.2**
Energy Use by Fuel Type (Quadrillion Btu)						
Motor Gasoline	15.9	18.9	18.5	18.5	16.1	16.1
Distillate	5.1	7.0	6.7	6.6	6.4	6.4
Jet Fuel	3.5	4.5	4.5	4.5	4.4	4.4
Residual Fuel	0.7	0.9	0.9	0.9	0.9	0.9
Other Petroleum	0.3	0.4	0.4	0.4	0.4	0.4
Petroleum Subtotal	*25.5*	*31.6*	*31.0*	*30.9*	*28.1*	*28.1*
Methanol (M85)	0.00	0.00	0.01	0.01	0.00	0.00
Ethanol (E85)	0.01	0.03	0.03	0.03	0.03	0.03
Electricity	0.06	0.12	0.10	0.10	0.10	0.10
Compressed Natural Gas	0.02	0.09	0.09	0.09	0.08	0.08
Liquid Hydrogen	0.00	0.00	0.01	0.01	0.01	0.01
Pipeline Fuel	0.7	0.9	0.9	1.0	0.9	0.9
Total	**26.3**	**32.8**	**32.0**	**32.1**	**29.2**	**29.2**
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**498**	**626**	**612**	**610**	**557**	**557**
		2020				
Energy Use by Mode (Quadrillion Btu)						
Light-Duty Vehicle	15.5	21.8	21.0	21.0	16.7	16.7
Heavy-Duty Vehicle	4.6	6.7	6.1	6.1	5.9	5.9
Air	3.5	6.0	5.9	5.9	5.7	5.7
Rail	0.6	0.7	0.7	0.6	0.6	0.5
Marine	1.3	1.5	1.5	1.5	1.5	1.5
Pipeline Fuel	0.7	1.1	1.0	1.0	0.9	1.0
Lubricants	0.2	0.3	0.3	0.3	0.3	0.3
Total	**26.3**	**38.2**	**36.3**	**36.3**	**31.5**	**31.5**
Energy Use by Fuel Type (Quadrillion Btu)						
Motor Gasoline	15.9	21.3	20.3	20.3	16.2	16.2
Distillate	5.1	8.2	7.6	7.5	7.1	7.0
Jet Fuel	3.5	6.0	5.9	5.9	5.7	5.7
Residual Fuel	0.7	0.9	0.9	0.9	0.9	0.9
Other Petroleum	0.3	0.4	0.4	0.4	0.4	0.4
Petroleum Subtotal	*25.5*	*36.7*	*35.0*	*34.9*	*30.2*	*30.2*
Methanol (M85)	0.00	0.00	0.01	0.01	0.01	0.01
Ethanol (E85)	0.01	0.04	0.06	0.06	0.05	0.05
Electricity	0.06	0.17	0.14	0.14	0.14	0.14
Compressed Natural Gas	0.02	0.16	0.15	0.15	0.13	0.13
Liquid Hydrogen	0.00	0.00	0.02	0.02	0.02	0.02
Pipeline Fuel	0.7	1.1	1.0	1.0	0.9	1.0
Total	**26.3**	**38.2**	**36.3**	**36.3**	**31.5**	**31.5**
CO_2 Emissions (Million Metric Tons Carbon Equivalent)	**498**	**730**	**684**	**682**	**593**	**593**

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

decrease in the initial overnight cost of the advanced fossil technologies and slight improvements in operating efficiency, or heat rates. For the advanced case in *CEF*, further improvements in heat rates were assumed, based on the Vision 21 program goals put forth by the DOE Office of Fossil Energy.

Since *AEO99*, the overnight costs have been updated for all technologies, and significant changes have been made to the representation of technology learning.[44] For the *CEF-JL* moderate and advanced cases, the assumptions for the overnight costs from the *AEO2001* high fossil case are used. In this case, capital costs are the same as in the reference case for all fossil technologies except integrated coal-gasification combined cycle, which has the same initial cost, but assumes costs will decline due to learning effects, resulting in a reduction in the overnight cost of 25 percent by 2020. Because the capital costs for new natural gas technologies that are achieved through the learning effects in NEMS are considered optimistic, no further reduction is made in the *AEO2001* high fossil case. These costs are somewhat higher than assumed in *AEO99* and in *CEF*. The *CEF-JL* advanced case assumes the same overnight costs as the *CEF-JL* moderate case.

The *CEF-JL* cases use the same input assumptions for fossil heat rates that were used in the *CEF* analysis. For the moderate case, this reflects a slight improvement of about 2 percent by 2010. In the advanced case, fairly significant improvements, in the range of 15 to 25 percent, are achieved by 2015. These assumptions in the advanced case are consistent with DOE's Office of Fossil Energy Vision 21 program goals and with the *AEO2001* high fossil case.[45] Achieving these program goals will require aggressive research and development of the technologies.

Enhanced Research and Development: Nuclear

The advanced nuclear technology cost assumption was changed in the *CEF* analysis. In the moderate case, the technological optimism multiplier, meant to adjust for the tendency to underestimate the cost increases for the first few plants of a new design, was removed, justified by the *CEF* authors by expected experience gained through international construction. This multiplier was 19 percent in *AEO99* and 15 percent in *AEO2001*. Since there have been no orders or construction of the specific advanced design being modeled (Westinghouse's AP600) anywhere in the world, this cost multiplier is not removed in the *CEF-JL* cases, achieving the same result in the *CEF* moderate case of no construction of new nuclear plants. In the *CEF* advanced case, the initial capital cost was reduced by 10 percent to reflect increased research and development, and this change is also in the *CEF-JL* advanced case.

Production Tax Credits for Renewables

There currently exists a production tax credit for new wind and closed-loop (dedicated energy use) biomass generation for plants completed by December 31, 2001. The credit is 1.5 cents per kilowatthour, in 1992 dollars, and is given to generators for the first 10 years of their operation. In the *CEF* moderate case, the production tax credit for wind and biomass plants was extended to all new plants through December 31, 2004. In the advanced case, this was extended to all nonhydropower renewables, including geothermal, municipal solid waste, and solar.

For the *CEF-JL* cases, the tax credits are incorporated in the same manner as in *CEF*-NEMS. However, in using the modeling structure of *AEO2001*, the minimum number of years estimated to license and complete new power plants using some renewable energy sources exceeds the remaining years of the tax credit, such that the first new power plants could not enter service until 2005, after the expiration of the credit. Therefore, for this case, new renewable plants are allowed to enter service one year earlier than in the reference case, reflecting the incentive that investors would have to complete the units in time to receive the tax credit. In both the *CEF-JL* moderate and advanced cases, a tax credit of 1.0 cent per kilowatthour, in 1992 dollars, is given to coal plants co-firing with biomass in the years 2000 through 2004, the same as in the *CEF* analysis.

Enhanced Research and Development: Renewables and Wind Deployment Facilitation

Many assumptions in the *CEF* analysis were adopted from the *AEO99* high renewables case. In addition, in order to increase the opportunity for wind power, the representation of wind resources and wind generating technologies was modified to lower costs and increase supplies by removing the 1000-megawatt-per-year limit on new wind capacity in any region, reducing the increases in wind capital costs that reflect resource limitations, transmission upgrades, and other market factors, and allowing intermittent wind resources to provide a greater share of overall generation. These modifications are described below.

For the *CEF-JL* cases, assumptions from the *AEO2001* high renewables case are generally used, except where more recent information is more favorable to

[44]Overnight costs are the costs of a new generating unit without including interest charges, contingencies, and overruns. Thus, they represent the costs if the unit could be built "overnight."

[45]Vision 21 is the research and development program for advanced coal and natural gas generating technologies.

renewables or when the *CEF* assumptions are more optimistic. Capital and fixed operating and maintenance costs in both the moderate and advanced cases are generally those used in the *AEO2001* high renewables case. However, the advanced case uses the *CEF* capital cost assumptions for wind power, which were much lower than the costs in the *AEO2001* high renewables case in the early years of the projections but declined much more slowly and by 2020 slightly exceeded the wind capital costs in the *AEO2001* high renewables case. The *CEF-JL* cases use the *CEF* moderate and advanced case capacity factor assumptions, which were taken from DOE's *Renewable Energy Technology Characterizations* and are also used for the *AEO2001* high renewables case. *AEO99* constrained the annual wind capacity growth to 1,000 megawatts in each region. However, this limit is not included in *AEO2001* nor in any of the cases in this analysis.

The *CEF* moderate and advanced cases included a capital cost increase (short-term elasticity) for renewable technologies, depending upon their annual rate of capacity growth in the United States when the annual growth rate exceeded 20 percent. For the *CEF-JL* cases, biomass and wind capital costs increase more slowly than assumed in *CEF*, a 0.5-percent cost increase for every 1 percent increase in annual capacity beyond 50 percent. Solar technology costs increase one percent for every 1 percent capacity expansion beyond 50 percent. These short-term elasticities do not apply to geothermal and hydropower. However, the *CEF-JL* cases limit annual U.S. growth of biomass capacity to 400 percent and wind capacity to 300 percent. The net effect in this analysis should be to make assumptions for renewables as favorable or somewhat more favorable overall than in the *CEF* moderate and advanced cases with respect to the above variables.

In *AEO99*, NEMS included a bound on the intermittent renewable technologies in which the sum of wind and solar generation in each region and each year was limited to a share of total electricity generation, excluding cogeneration. In addition, NEMS apportioned wind resources in each region and applied higher capital costs to each resource portion up to a maximum capital cost increase of 200 percent. These cost increases were meant to reflect the increasing costs of natural resource limitations, upgrades to the existing transmission network, and environmental and other market issues. In the *CEF* analysis, the intermittency bound was completely removed, and the capital cost increases on wind were reduced to a maximum of 60 percent to reflect these costs and the costs of turbine backup and other ancillary costs. Natural resource, transmission, and market costs can reach a maximum of 20 percent, or one-third, of the total maximum capital cost increase in the *CEF* analysis. The *CEF* modifications are incorporated in the current version of NEMS for the *CEF-JL* cases, with the effect of significantly increasing wind supply by lowering the assumed cost of natural resource, transmission, and other market factors.

Although the *CEF* capital cost modifications are incorporated in the *CEF-JL* moderate and advanced cases, the *CEF* assumptions understated important costs necessary in evaluating actual U.S. wind supply. The *CEF* analysis greatly reduced capital cost adjustment factors in NEMS, which were designed to reflect natural resource, transmission, and market factors that add to the cost of wind power, and instead portrayed them primarily as accounting for increasing intermittency costs only. In so doing, the *CEF* analysis provided a useful portrayal of intermittency costs but underestimated more important and greater costs encountered in actual wind power markets.

In wind power markets, natural resource impediments are significant and serve to distinguish low-cost from high-cost sites, including variations in wind quality (peak, off peak), soil (often rock), slope (affecting road and construction cost), weather (moisture, temperature, icing, insects, and storms), and vegetation. Variations affect both the cost of building wind power plants and also their productivity and the costs of accessing and maintaining them. Furthermore, limits on the existing transmission network, separate from interconnection costs, are proving to raise significant barriers to large-scale wind power expansion in all three primary wind areas of the United States (the Midwest, the Northwest and the Southwest), because existing transmission lines lack available capacity for the additional wind power and because increases in uncertain and varying wind power affect the stability of the overall transmission system. Finally, wind power must compete with other interests for the use of land, increasing the costs of wind power as applications expand. Even relatively early in U.S. wind power development, scenic, environmental, and other preferences have been found to be powerful, effective, and costly competitors to wind power expansion. By understating the effects of these factors on the costs of wind power, the *CEF* assumptions overestimated overall U.S. wind supply and underestimated wind power costs.

Renewable Portfolio Standard

CEF included a renewable portfolio standard (requiring a specified percentage of electricity sales to be generated from renewable sources other than hydropower) in the advanced case only. In the *AEO99* version of NEMS, a renewable portfolio standard with a limit on the credit price could not be implemented. Therefore, *CEF*-NEMS modeled a surrogate for a renewable portfolio standard through an extension of the production tax credit until 2008 and an extension of the co-firing credit through 2014. The intention was a 7.5-percent renewable portfolio standard by 2010, maintained through 2015 and subject to a 1.5-cents-per-kilowatthour limit on the credit price. Since NEMS can now explicitly implement this standard, the 7.5-percent renewable portfolio standard is included in the *CEF-JL* advanced case as intended in the *CEF* analysis.

Full National Restructuring

In both the *CEF* moderate and advanced cases, nationwide restructuring of the electricity industry was assumed. This implied that electricity prices would be based on marginal costs, rather than regulated, cost-of-service pricing. The reference case assumes a transition to full competitive pricing in California, New York, New England, the Mid-Atlantic Area Council, and Texas. In addition, electricity prices in the East Central Area Reliability Council, the Mid-America Interconnected Network, the Southwest Power Pool, and the Rocky Mountain Power Area / Arizona (Arizona, New Mexico, Colorado, and eastern Wyoming) regions are assumed to be partially competitive. Some of the States in each of these regions have not taken action to deregulate their pricing of electricity, and in those States prices are assumed to continue to be based on traditional cost-of-service pricing.

The *CEF-JL* cases assume all regions transition to competitive pricing, although the timing of the transition period is delayed slightly based on current assumptions regarding the start of deregulation. Also, there are two regions that have a significant portion of their electricity generated by Federal facilities, which are not a part of deregulation. In those regions, the Southeastern Electric Reliability Council, excluding Florida, and the Northwest Power Pool Area, a portion of the region remains at cost-of-service pricing based on the share of sales met by the Federal facilities. All other regions are assumed to reach 100-percent competitive pricing. Although the *CEF* report discussed changes in discount rates and reserve margins due to restructuring, these changes were not documented. Discussions with *CEF* analysts indicated that no other changes were made to reflect electricity restructuring.

Enhanced Research and Development: Sequestration

The *CEF* authors assumed that technologies using sequestration of CO_2 were allowed to enter the market starting in 2010. The integrated coal-gasification combined cycle and advanced natural gas combined cycle plants were assumed to have higher variable costs due to sequestration, based on a cost of $50 per metric ton carbon equivalent removed. Cost estimates for sequestration methods are very uncertain, due to the lack of experience with the technology. Since the modifications required for sequestration are more like capital investment rather than an increment to the annual operating cost, the *CEF* assumptions are converted to a capital cost adjustment for implementation in the *CEF-JL* advanced case. The additional variable costs are calculated over twenty years and a net present value calculation determines the capital cost adjustments, $550 per kilowatt for integrated coal-gasification combined cycle plants and $270 per kilowatt for advanced combined cycle plants.

These capital cost adjustments are similar in magnitude to those used by EIA in a previous analysis report.[46] However, the EIA analysis includes additional operating costs for the sequestration technology, as well as the capital cost investment. The previous analysis also found that the process of capturing CO_2 greatly reduces the efficiency of the plant, so adjustments are made to heat rates. The *CEF* authors assumed the same heat rate could be achieved by plants using sequestration technology as those without sequestration, which is unlikely.

SO_2 Reductions

As a means of representing tighter standards on particulate matter, the *CEF* advanced case reduced the SO_2 ceiling by 50 percent from the level currently mandated by Phase 2 of CAAA90 (8.95 million tons), declining in steps to 4.48 million tons. The reductions occurred between 2010 and 2020. This particulate matter policy was implemented through SO_2 reductions because particulate matter is likely to be controlled through tighter limits on SO_2 and NO_x since particulates are primarily a byproduct of coal use for electricity generation, although they are also a byproduct of natural gas use. This policy is implemented in the same manner in the *CEF-JL* advanced case.

Impact of *CEF* Policies on Electricity and Renewables Markets

The *CEF-JL* cases have impacts on projected electricity prices in 2020 ranging from a slight reduction in the moderate case to an 8-percent increase in the advanced case (Figure 28 and Table 30). The cost and performance improvements together with the production tax credits for selected renewable technologies result in slightly lower prices in the moderate case. However, the addition of the carbon fee of $50 per metric ton carbon equivalent in the advanced case raises projected electricity prices.

Because of policies in the end-use sectors to reduce energy consumption and the electricity price increases in the advanced case which encourage some additional reductions in the demand for electricity, projected sales

[46]Energy Information Administration, *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*, SR / OIAF / 98-03 (Washington, DC, October 1998), web site www.eia.doe.gov / oiaf / kyoto / kyotorpt.html.

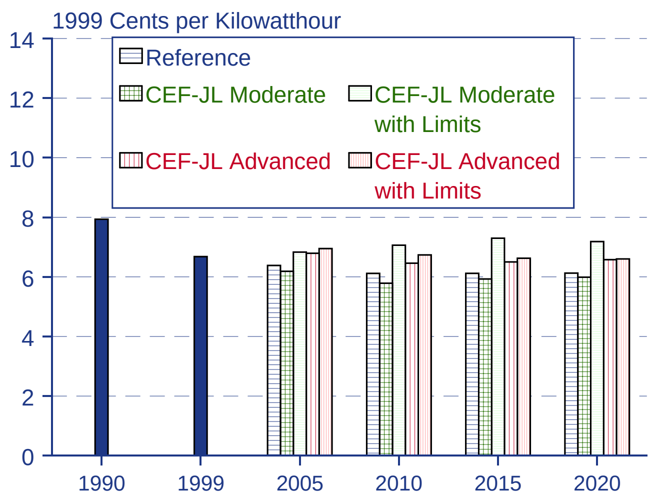
of electricity in 2020 are substantially lower in the *CEF-JL* cases, ranging from 12 percent in the moderate case to 19 percent in the advanced case, compared to the reference case (Figure 29). The *CEF-JL* cases result in annual growth rates of projected electricity sales that are greatly reduced, averaging 1.2 and 0.8 percent in the moderate and advanced cases, respectively, compared with 1.8 percent per year in the reference case. These projected reductions result from *CEF* policies regarding adoption and penetration of more energy-efficient technologies driven by efficiency standards, building codes, financial incentives, research and development, and voluntary agreements and deployment programs, as discussed earlier in this chapter.

The lower levels of projected electricity consumption in the *CEF-JL* cases are expected to reduce the use of fossil fuels to generate electricity (Figure 30). Projected coal-fired generation, which is about the same in the *CEF-JL* moderate case as in the reference case, is 32 percent lower in the *CEF-JL* advanced case in 2020. The projected reduction in the advanced case is partly in response to the carbon fee which makes coal less economic compared with other generating technologies and the policy to reduce particulate emissions. Similarly, projected natural-gas-fired generation declines by 39 percent in the moderate case and by 21 percent in the advanced case in 2020, compared to the reference case. The reduced generation for natural gas is expected to occur because fewer new plants are needed to meet the lower growth in projected electricity demand in the *CEF-JL* cases. However, in the *CEF-JL* advanced case, there are a variety of policies that encourage the use of natural gas and renewable generation instead of coal-fired generation, including the $50 carbon fee and particulate reductions. Nuclear generation is also projected to be lower in 2020 by 2 percent and 6 percent in the *CEF-JL* moderate and advanced cases, respectively, primarily due to the lower generation requirements.

Renewable generating technologies are expected to make little additional contribution in the *CEF-JL* moderate case because natural-gas-fired turbines and combined-cycle plants are still more economic than renewable technologies even with the production tax credits for wind and biomass. However, in the *CEF-JL* advanced case nonhydropower renewable technologies are expected to provide 250 billion kilowatthours of generation, 151 billion kilowatthours more generation in 2020 than in the reference case, due to the extension of the production tax credit for additional renewable technologies, a renewable portfolio standard, and the fee of $50 per metric ton carbon equivalent. As a result, these renewable technologies are expected to increase generation by about 150 percent in 2020 in the *CEF-JL* advanced case, compared to the reference case. Additional generation from wind power accounts for 58 percent of the increase, with biomass, particularly biomass co-fired with coal, providing 21 percent, and geothermal 16 percent of the increase relative to the reference case.

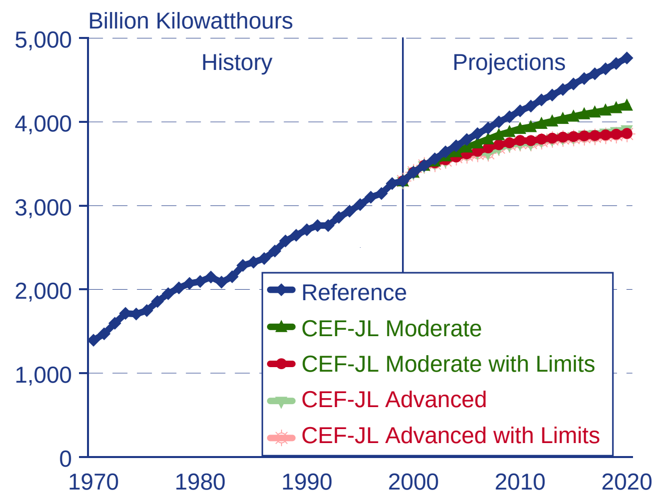
In 2020, projected CO_2 emissions from electricity generation, excluding cogenerators, are reduced by 9 and 32 percent in the moderate and advanced cases, respectively, relative to the reference case.

Figure 28. Average Delivered Electricity Prices in Five Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 29. Electricity Sales in Five Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Table 30. Electricity Projections in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
				2010		
Average Delivered Electricity Prices (1999 Cents per Kilowatthour)	6.7	6.1	5.8	7.1	6.5	6.7
Electricity Sales (Billion Kilowatthours)	3,294	4,133	3,920	3,747	3,777	3,745
Generation, Excluding Cogenerators (Billion Kilowatthours)	**3,369**	**4,204**	**3,983**	**3,788**	**3,838**	**3,807**
Coal	1,830	2,238	2,221	1,357	1,737	1,395
Natural Gas	370	826	616	1,138	800	1,090
Nuclear Power	730	720	720	741	735	735
Renewables, Excluding Hydropower	46	95	105	240	253	277
Hydropower	310	301	301	302	302	302
Emissions, Excluding Cogenerators						
SO_2 (Million Tons)	13.5	9.7	9.7	3.0	9.7	3.0
NO_x (Million Tons)	5.4	4.3	4.2	1.7	3.5	1.8
Hg (Tons)	43.4	45.5	45.7	4.3	38.6	4.3
CO_2 (Million Metric Tons Carbon Equivalent)	556	691	658	474	538	475
Allowance Prices						
SO_2 (1999 Dollars per Ton)	0	180	169	316	102	130
NO_x (1999 Dollars per Ton)[a]	0	0	0	0	0	0
Hg (Million 1999 Dollars per Ton)	0	0	0	549	0	481
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	0	64	50	55
Annual Household Electricity Bill (1999 Dollars)	**892**	**936**	**850**	**940**	**882**	**894**
Total Electricity Revenue (Billion 1999 Dollars)	**222**	**252**	**227**	**266**	**246**	**251**
				2020		
Average Delivered Electricity Prices (1999 Cents per Kilowatthour)	6.7	6.1	6.0	7.2	6.6	6.6
Electricity Sales (Billion Kilowatthours)	3,294	4,763	4,197	3,910	3,862	3,855
Generation, Excluding Cogenerators (Billion Kilowatthours)	**3,369**	**4,821**	**4,231**	**3,893**	**3,883**	**3,878**
Coal	1,830	2,302	2,296	1,284	1,567	1,276
Natural Gas	370	1,488	908	1,330	1,181	1,416
Nuclear Power	730	610	595	646	575	617
Renewables, Excluding Hydropower	46	99	113	323	250	260
Hydropower	310	300	300	301	301	301
Emissions, Excluding Cogenerators						
SO_2 (Million Tons)	13.5	9.0	9.0	2.2	4.5	2.2
NO_x (Million Tons)	5.4	4.5	4.3	1.7	3.2	1.6
Hg (Tons)	43.4	45.2	46.2	4.3	29.4	4.3
CO_2 (Million Metric Tons Carbon Equivalent)	556	773	706	474	524	469
Allowance Prices						
SO_2 (1999 Dollars per Ton)	0	200	184	905	707	670
NO_x (1999 Dollars per Ton)[a]	0	0	0	81	0	0
Hg (Million 1999 Dollars per Ton)	0	0	0	468	0	391
CO_2 (1999 Dollars per Metric Ton Carbon Equivalent)	0	0	0	68	50	50
Annual Household Electricity Bill (1999 Dollars)	**892**	**980**	**825**	**884**	**779**	**777**
Total Electricity Revenue (Billion 1999 Dollars)	**222**	**291**	**252**	**282**	**255**	**254**
Cumulative Additions of Emissions Control Equipment, 1999-2020 (Gigawatts)						
SO_2 Scrubbers	—	17.5	9.5	54.9	12.1	52.7
Selective Catalytic Reduction (SCRs)	—	91.1	89.9	112.3	78.6	101.6
Selective Noncatalytic Reduction (SNCRs)	—	46.0	31.9	33.6	33.9	43.4
Hg Fabric Filters	—	0.0	0.0	100.4	0.0	115.5
Hg Spray Coolers	—	0.0	0.0	57.5	0.0	98.3
Cumulative Resource Cost, 2001-2020 (Billion 1999 Dollars)	**—**	**2,031**	**1,751**	**1,913**	**1,682**	**1,811**

[a]Regional NO_x limits are included in the reference case, but the corresponding allowance costs are not included in the table because they are not comparable to a national NO_x limit.

Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Impact of Emissions Limits on Electricity and Renewables Markets in the *CEF-JL* Cases

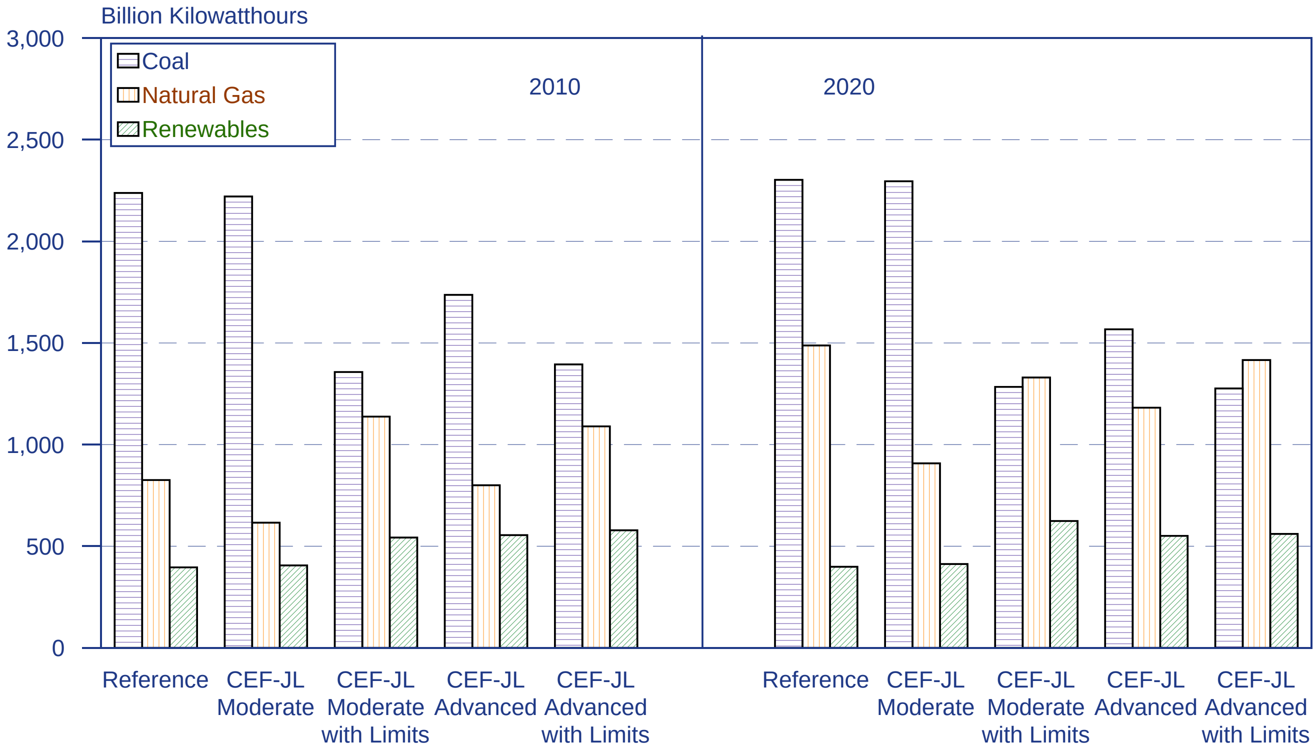
Prices for electricity are generally projected to increase when emissions limits are added to the *CEF-JL* moderate and advanced cases. In the *CEF-JL* moderate case with emissions limits, projected average delivered electricity prices in 2020 reach 7.2 cents per kilowatthour compared to 6.0 cents per kilowatthour in the case without emissions limits, due principally to the costs of meeting the requirements for reductions in CO_2 emissions. In the *CEF-JL* advanced case with limits, the electricity price is projected to be 6.6 cents per kilowatthour, the same as in the *CEF-JL* advanced case without emissions limits.

As in other cases in this report, higher projected electricity prices result in lower levels of electricity sales. In the *CEF-JL* moderate case with emissions limits, projected electricity demand in 2020 is reduced by 7 percent, compared to the case without emissions limits, as a result of consumer responses to higher prices. In the *CEF-JL* advanced case with emissions limits, where projected electricity prices in 2020 are the same as those in the case without limits, projected electricity sales are essentially the same.

The addition of emissions limits to the *CEF-JL* cases is projected to result in less generation from coal and more generation from natural gas. The limits on emissions of CO_2 add to the costs of coal-fired generation making it less attractive compared with natural gas. No new coal plants are expected to be constructed, and more existing coal plants are expected to be retired in the *CEF-JL* cases when emissions limits are imposed. Although natural-gas-fired plants are projected to experience some increases in costs for complying with CO_2 emissions limits, their costs are less than for coal plants because of the lower carbon content of natural gas compared with coal.

In the *CEF-JL* cases with emissions limits, renewable technologies are expected to provide more generation than in the cases without limits, particularly in the moderate case. In the *CEF-JL* moderate case, the CO_2 allowance costs increase the costs of fossil-fired technologies and, as a result, makes the costs of renewable technologies more competitive. Nonhydropower renewable technologies are projected to increase their generation by 210 billion kilowatthours, or 187 percent, in 2020 in the *CEF-JL* moderate case with emissions limits, compared to the case without limits. Only modest increases in renewable generation are projected in the *CEF-JL* advanced case with limits because the advanced case

Figure 30. Projected Electricity Generation from Coal, Natural Gas, and Renewable Fuels (Excluding Cogenerators) in Five Cases, 2010 and 2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

without limits already includes a carbon fee. In 2020, nuclear generation is projected to be higher by 9 percent and 7 percent in the *CEF-JL* moderate and advanced cases with emissions limits, compared to the cases without emissions limits as a result of fewer retirements of nuclear plants due to the improved economics of nuclear power relative to fossil-fired generation.

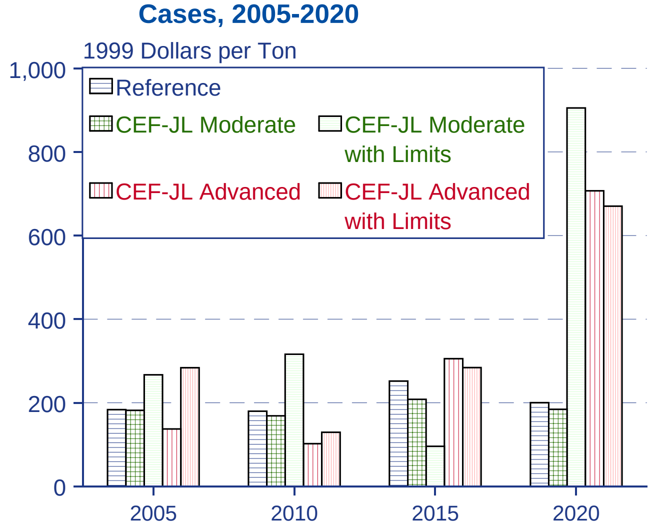
In both the *CEF-JL* moderate and advanced cases, more emission control equipment is projected to be built to reduce emissions of SO_2, NO_x, and Hg when the emissions limits are imposed. About 45 gigawatts of additional SO_2 scrubbers are expected to be constructed in both the *CEF-JL* moderate and advanced cases when the emissions limits are added in order to meet the reduced limits on SO_2 emissions. Similarly, there is also more construction of selective catalytic reduction and selective noncatalytic reduction facilities to meet more stringent reductions in NO_x emissions and investments in fabric filters and spray coolers to reduce emissions of Hg. The lower level of investments for SO_2 controls in the *CEF-JL* advanced case compared with the *CEF-JL* moderate case reflects the lower levels of coal-fired generation that reduce the need to limit emissions. However, there are offsetting additional investments in controls for Hg. These investments are less capital-intensive options compared with those for SO_2 controls.

The costs of SO_2 allowances in 2020 are projected to increase in the moderate case with emissions limits and decrease somewhat in the advanced case with emissions limits. In the *CEF-JL* moderate case with limits, the allowance price is projected to be $905 per ton in 2020, compared to $184 per ton in the case without limits (Figure 31). The projected allowance price in 2020 is $670 and $707 per ton in the *CEF-JL* advanced case, with and without the emissions limits, respectively. The higher projected costs in the *CEF-JL* moderate case reflect the costs of additional emission control equipment constructed to reduce both SO_2 and Hg emissions. In the *CEF-JL* advanced case, the projected allowance price is lower when the emissions limits are imposed, because the limits on CO_2 emissions lower coal use, making it easier to meet the SO_2 limits. In the *CEF-JL* moderate case with emissions limits, the NO_x allowance price is projected to be $81 per ton; however, in the *CEF-JL* advanced case, the projected costs for NO_x permits decline to zero because the actions taken to reduce CO_2 reductions result in NO_x emission levels within the specified limit (Figure 32). Hg allowance costs are projected to be $468 and $391 million per ton in 2020 in the *CEF-JL* moderate and advanced cases with emissions limits, respectively (Figure 33). These costs reflect the cost of adding emission control equipment, such as spray cooling and fabric filters.

Emissions limits on CO_2 result in projected allowance prices in 2020 of $68 per metric ton carbon equivalent and $50 per metric ton carbon equivalent in the *CEF-JL* moderate and advanced cases with emissions limits, respectively (Figure 34). Because the CO_2 allowance price is the same in the *CEF-JL* advanced cases with and without limits, average delivered electricity prices are expected be the same. Projected CO_2 emissions from electricity generators, excluding cogenerators, are reduced by 33 percent and 10 percent in the *CEF-JL* moderate and advanced cases with emissions limits, respectively, compared to the cases without emissions limits.

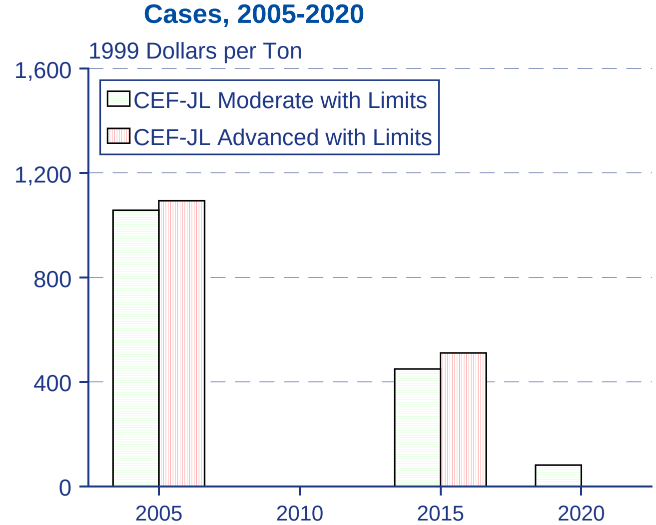
The cumulative incremental resource costs to electricity generators from 2001 to 2020 to comply with the emissions limits are projected to be $162 billion and $129 billion in the *CEF-JL* moderate and advanced cases, respectively (Figure 35), representing increases of about

Figure 31. Sulfur Dioxide Allowance Price in Five Cases, 2005-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 32. Nitrogen Oxides Allowance Price in Two Cases, 2005-2020

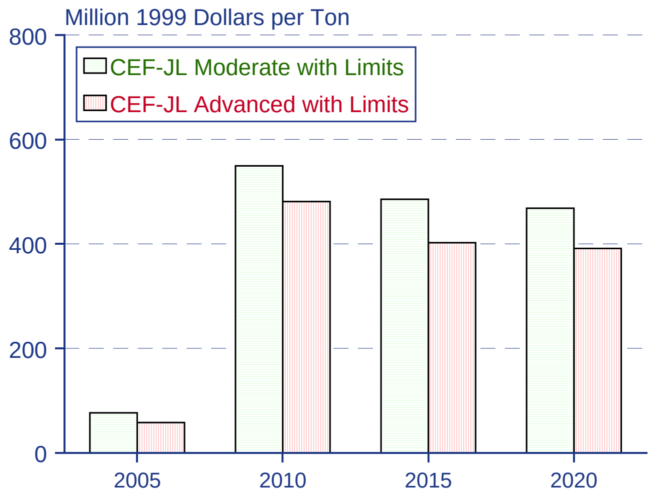


Source: National Energy Modeling System, runs SCENCEM.D081601A and SCENDEMR.D092701A.

9 and 8 percent, respectively. The lower projected cost of compliance in the *CEF-JL* advanced case is due to the availability of more advanced generating technologies compared to the *CEF-JL* moderate case. In addition, because lower SO_2 emissions are assumed in the *CEF-JL* advanced case even without the emissions limits to simulate the impact of particulate controls, the additional emissions limits can be achieved at a lower relative cost.

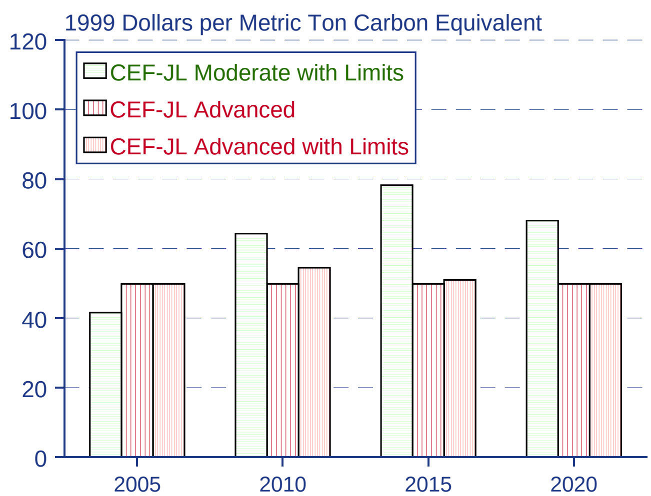
The annualized resource costs, which include financing and capital recovery costs, are projected to increase in the *CEF-JL* moderate case by $18.5 billion in 2007, when the limits are imposed. These incremental costs are projected to decline to $18.1 billion and $14.3 billion in 2010 and 2020, respectively. Similar to the cumulative resource costs, the incremental annualized resource costs due to emissions limits are lower in the *CEF-JL* advanced case than in the *CEF-JL* moderate case, $15.8 billion in 2007, declining to $14.5 billion in 2010 and $11.9 billion in 2020.

Figure 33. Mercury Allowance Price in Two Cases, 2005-2020



Source: National Energy Modeling System, runs SCENCEM.D081601A and SCENDEMR.D092701A.

Figure 34. Carbon Dioxide Allowance Price in Three Cases, 2005-2020



Source: National Energy Modeling System, runs SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Impact of *CEF* Policies and Emissions Limits on Fossil Fuel Markets

CEF did not include any policies to change the available supply of natural gas or coal but introduced policies to reduce overall energy consumption and change the fuel mix in energy markets. Incorporating the *CEF* policies in the *CEF-JL* cases impacts both natural gas and coal markets as a result of efficiency improvements, demand reductions, and fuel switching.

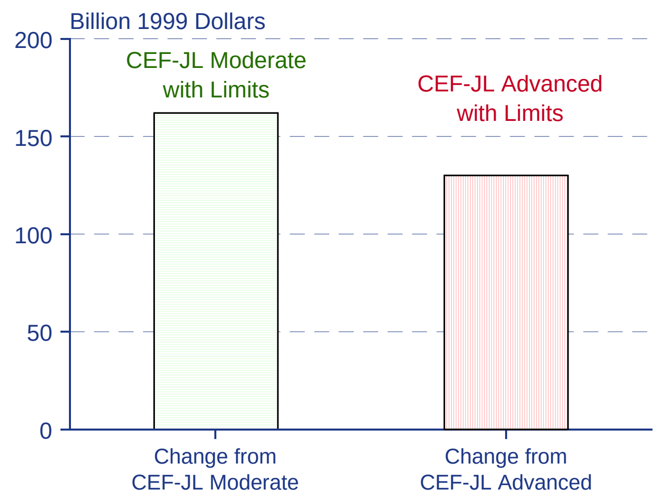
Natural Gas

Impact of CEF Policies on Natural Gas Markets

In 2020, projected natural gas consumption is 30.6 trillion cubic feet in the *CEF-JL* moderate case, compared to 35.0 trillion cubic feet in the reference case (Table 31). Most of the reduction in demand is in the electricity generation sector. In the *CEF-JL* advanced cases, natural gas consumption is projected to be further reduced to 29.9 trillion cubic feet in 2020.

The reduction in natural gas consumption that results from the *CEF* policies is projected to reduce natural gas production and substantially reduce prices. By 2020, total domestic natural gas production is projected to be 25.5 and 24.9 trillion cubic feet in the *CEF-JL* moderate and advanced cases, respectively, compared to 29.3 trillion cubic feet in the reference case (Figure 36). As a

Figure 35. Impacts of Emission Limits on Cumulative Resource Costs for Electricity Generation, 2001-2020



Source: National Energy Modeling System, runs SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

result of the lower demand and production, the wellhead natural gas price is projected to be $2.48 per thousand cubic feet in the *CEF-JL* moderate case and $2.36 per thousand cubic feet in the *CEF-JL* advanced case, compared to $3.10 per thousand cubic feet in the reference case (Figure 37). Lower wellhead prices lead to a 9-percent decrease in the residential price in the *CEF-JL* moderate case, compared to the reference case; however, in the *CEF-JL* advanced case, which includes the $50 carbon fee, the effective residential natural gas price in 2020 is projected to be almost the same as in the reference case. Although the projected wellhead prices in the

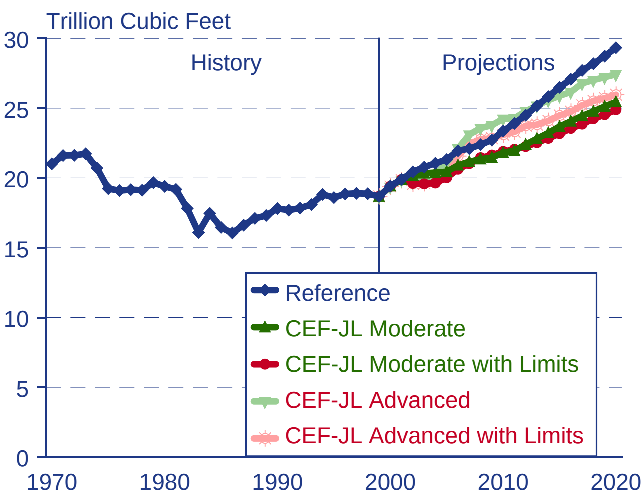
Table 31. Natural Gas Market Projections in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
			2010			
Average Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	2.82	2.45	2.91	2.28	2.76
Delivered Price to Electricity Generators (1999 Dollars per Thousand Cubic Feet)	2.62	3.30	2.88	3.66	2.86	3.48
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Thousand Cubic Feet)	2.62	3.30	2.88	4.61	3.59	4.28
Consumption by Electricity Generators, Excluding Cogenerators (Trillion Cubic Feet)	3.8	6.8	5.4	8.1	5.8	7.4
Total Consumption (Trillion Cubic Feet)	21.8	28.2	26.4	29.2	26.4	27.9
Domestic Production (Trillion Cubic Feet)	18.7	23.4	21.8	24.2	21.9	23.1
			2020			
Average Wellhead Price (1999 Dollars per Thousand Cubic Feet)	2.08	3.10	2.48	2.82	2.36	2.61
Delivered Price to Electricity Generators (1999 Dollars per Thousand Cubic Feet)	2.62	3.68	2.91	3.57	2.96	3.33
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Thousand Cubic Feet)	2.62	3.68	2.91	4.57	3.70	4.06
Consumption by Electricity Generators, Excluding Cogenerators (Trillion Cubic Feet)	3.8	11.2	7.4	9.4	7.7	9.2
Total Consumption (Trillion Cubic Feet)	21.8	35.0	30.6	32.9	29.9	31.2
Domestic Production (Trillion Cubic Feet)	18.7	29.3	25.5	27.4	24.9	26.0

[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.

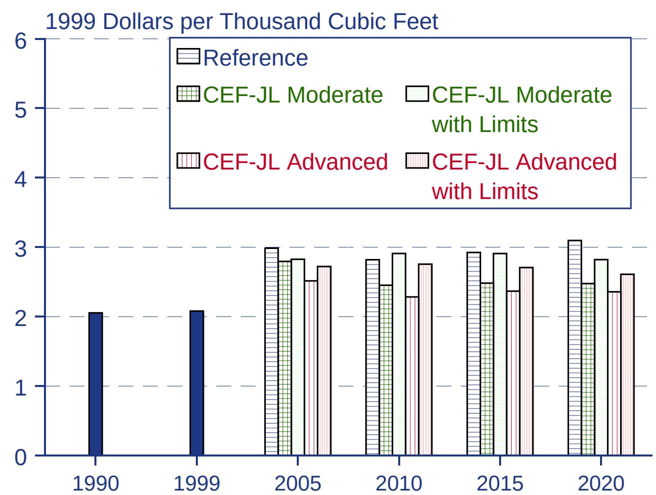
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 36. Natural Gas Production in Five Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 37. Natural Gas Wellhead Prices in Five Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

CEF-JL cases are lower than in the reference case, projected real prices in 2020 are still higher than they were during many of the years in the late 1990s.

Impact of Emissions Limits on Natural Gas Markets in the CEF-JL Cases

Similar to the reference case, imposing the emissions limits results in higher projected natural gas prices and consumption in both the *CEF-JL* moderate and advanced cases, due primarily to higher consumption of natural gas by electricity generators but also due to higher cogeneration in the moderate case. However, even with the higher projected demands in the *CEF-JL* moderate and advanced cases with the emissions limits, compared to the cases without limits, total natural gas consumption and average wellhead prices in 2020 are projected to remain lower than in the reference case.

In the *CEF-JL* moderate case, the projected total consumption of natural gas in 2020 increases from 30.6 trillion cubic feet without the emissions limits to 32.9 trillion cubic feet with the emissions limits, with 1.9 trillion cubic feet of this increase resulting from additional electric generator demand. As a result of the higher demand, the average wellhead price of natural gas in 2020 is projected to increase to $2.82 per thousand cubic feet in the case with emissions limits, compared to $2.48 per thousand cubic feet in the case without emissions limits.

Most of the projected additional demand in the case with the emissions limits is met by increased projected domestic production. Production is projected to reach 27.4 trillion cubic feet in 2020 in the case with the emissions limits, 2.0 trillion cubic feet higher than projected in the case without emissions limits. Similar to the advanced technology case, the increased consumption that results from imposing emissions limits on the *CEF-JL* moderate case does not raise natural gas prices high enough to make additional supplies from Mexico, Alaska, or as liquefied natural gas competitive, and therefore most of the projected growth of supply comes from lower-48 production.

Early in the forecast period, projected natural gas production in the *CEF-JL* moderate case with emissions limits is higher than in the reference case for a few years as electricity generators switch to natural gas to meet the limits. Later in the period, natural gas production and consumption are projected to be lower than in the reference case, and generation requirements are reduced.

The impacts of emissions limits in the *CEF-JL* advanced case are similar to those in the *CEF-JL* moderate case. With projected electric generator natural gas demand increasing from 7.7 to 9.2 trillion cubic feet in 2020 between the case without and with the emissions limits, total consumption is projected to increase from 29.9 to 31.2 trillion cubic feet. Almost all of the additional natural gas required due to the emissions limits is supplied by increased domestic production. By 2020, the projected wellhead price is $2.61 per thousand cubic feet, compared to $2.36 per thousand cubic feet in the *CEF-JL* advanced case without emissions limits. With the emissions limits, the effective residential price of natural gas is projected to reach $7.05 per thousand cubic feet in 2020, compared to $6.77 per thousand cubic feet in the *CEF-JL* advanced case without emissions limits, including the CO_2 allowance cost. This is $0.31, or 5 percent, higher than the residential price projected in the reference case.

Coal

Impact of CEF Policies on Coal Markets

The policies in the *CEF-JL* moderate case generally have a slight impact on coal markets relative to the reference case. Electricity sales are projected to decline as a result of increased adoption of energy-efficient technologies; however, coal is projected to gain market share in the electricity generation market, and projected coal consumption in the generation sector increases at an average annual rate of 1.1 percent over the forecast period, compared to 1.2 percent in the reference case (Table 32).

Several policies in the *CEF-JL* advanced case affect the level of coal-fired electricity generation, including the $50 carbon fee and the reduction in SO_2 emissions to represent tighter particulate matter standards. In addition, various policies for expanding generation by renewable energy sources are introduced or have their expiration dates extended beyond the time period established in the *CEF-JL* moderate case, resulting in an increase of the share of generation from nonhydropower renewable sources.

In the *CEF-JL* advanced case, cumulative retirements of coal plants are projected to total 35 gigawatts by 2020, compared to approximately 7 gigawatts in the reference case. In 2020, coal consumption by electricity generators is projected to decline to 814 million short tons, compared to 1,190 million short tons in the reference case and 1,167 million short tons in the *CEF-JL* moderate case, reducing both coal production and prices (Figures 38 and 39). The more stringent SO_2 requirement leads to a strong shift to sources of low-sulfur coal in the West and results in coal inputs to generators that average 1.5 pounds of SO_2 per million Btu compared to 1.7 pounds in the reference case. Because western coal, with the exception of lignite, also contains lower amounts of Hg and is projected to increase its share of total production, the average Hg content of coal used for electricity generation declines from levels in the *CEF-JL* moderate case.

Impact of Emissions Limits on Coal Markets in the CEF-JL Cases

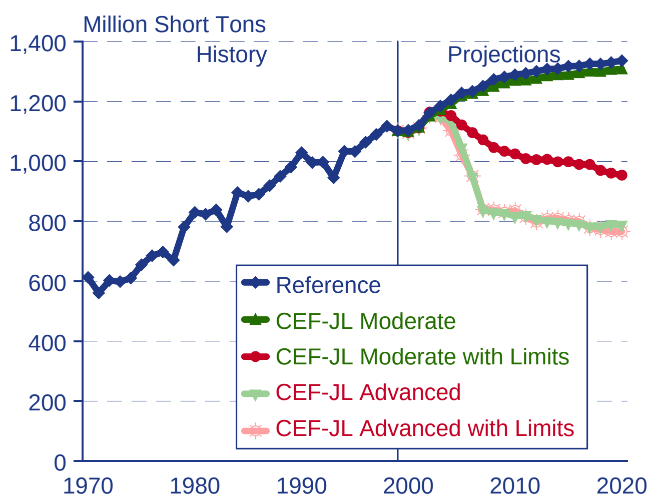
The introduction of emissions limits in the *CEF-JL* moderate and advanced cases is projected to reduce coal consumption by electricity generators in 2020 by 46 percent and 23 percent, respectively, relative to the same cases without the emissions limits. In 2020, the projected CO_2 allowance cost to electricity generators is lower in the *CEF-JL* advanced case with emissions limits than in the *CEF-JL* moderate case with emissions limits, $1.27 per million Btu versus $1.74 per million Btu, because the additional policies to reduce SO_2 and promote renewables are projected to result in a greater reduction in coal consumption and lower CO_2 emissions.

Table 32. Coal Market Projections in the *CEF-JL* Moderate and Advanced Cases, 2010 and 2020

Projections	1999	Reference	*CEF-JL* Moderate: Without Emissions Limits	*CEF-JL* Moderate: With Emissions Limits	*CEF-JL* Advanced: Without Emissions Limits	*CEF-JL* Advanced: With Emissions Limits
		2010				
Consumption by Electricity Generators, Excluding Cogenerators (Million Short Tons)	920	1,139	1,121	658	876	687
Production (Million Short Tons)	1,102	1,289	1,270	817	1,025	836
Minemouth Price (1999 Dollars per Short Ton)	17.13	14.19	13.93	15.08	13.88	14.27
Delivered Price to Electricity Generators (1999 Dollars per Million Btu)	1.21	1.06	1.05	1.00	1.02	1.00
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Million Btu)	1.21	1.06	1.05	2.64	2.30	2.39
Average SO_2 Content (Pounds per Million Btu)	2.0	1.8	1.8	1.8	1.9	1.8
Average Hg Content (Pounds per Trillion Btu)	7.7	7.2	7.2	6.1	7.6	6.2
CO_2 Allowance Cost (1999 Dollars per Million Btu)	0.00	0.00	0.00	1.64	1.27	1.39
		2020				
Consumption by Electricity Generators, Excluding Cogenerators (Million Short Tons)	920	1,190	1,167	633	814	625
Production (Million Short Tons)	1,102	1,336	1,308	788	954	766
Minemouth Price (1999 Dollars per Short Ton)	17.13	12.93	12.78	13.47	11.51	13.45
Delivered Price to Electricity Generators (1999 Dollars per Million Btu)	1.21	0.98	0.96	0.92	0.93	0.89
Effective Delivered Price to Electricity Generators[a] (1999 Dollars per Million Btu)	1.21	0.98	0.96	2.66	2.21	2.16
Average SO_2 Content (Pounds per Million Btu)	2.0	1.7	1.7	1.7	1.5	1.8
Average Hg Content (Pounds per Trillion Btu)	7.7	7.1	7.1	6.1	7.0	6.2
CO_2 Allowance Cost (1999 Dollars per Million Btu)	0.00	0.00	0.00	1.74	1.28	1.27

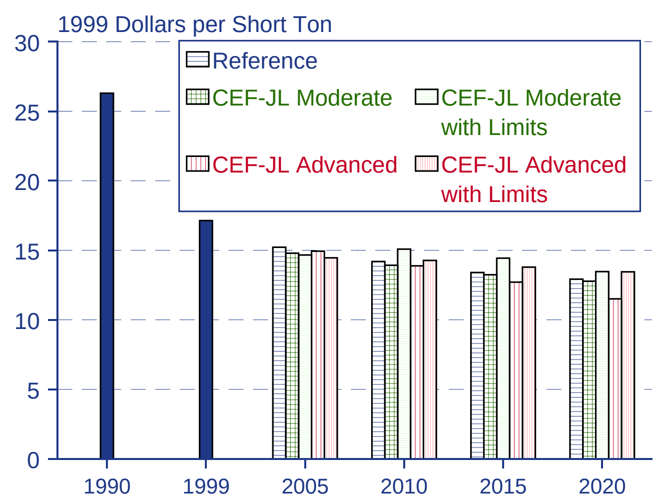
[a]Effective delivered price reflects the cost impact of CO_2 emission allowances in cases that include a CO_2 limit.
Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 38. Coal Production in Five Cases, 1970-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Figure 39. Coal Minemouth Prices in Five Cases, 1990-2020



Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

In the *CEF-JL* moderate and advanced cases with emissions limits, projected coal production in 2020 declines to levels that are 60 percent and 80 percent, respectively, of the coal production in the cases without the limits. Total domestic coal consumption is projected to be lower in the *CEF-JL* advanced case with emissions limits because it includes stronger policies promoting renewable generation sources, which lead to some additional displacement of coal generation. In addition, the application of a $50 carbon fee to the industrial and coking coal sectors is projected to result in reduced consumption of 16 million short tons of higher-sulfur coal in these sectors. Retrofits of scrubbers are projected to be 2 gigawatts less in the *CEF-JL* advanced case with emissions limits, compared to the *CEF-JL* moderate case with emissions limits.

Macroeconomic Impacts

This section analyzes the macroeconomic impacts of emissions limits in the *CEF-JL* cases, using the same methodology described in Chapter 2 for the reference and advanced technology cases, with a marketable emissions permit system and a no-cost allocation of permits.

Macroeconomic Impacts of Emissions Limits on the *CEF-JL* Moderate Case

The *CEF-JL* moderate case incorporates numerous policies to reduce energy consumption and emissions relative to the reference case, which would make the attainment of emissions limits less difficult for the aggregate economy. The introduction of emissions limits in the *CEF-JL* moderate case results in a substantial increase in energy prices and subsequently for aggregate prices for the economy. In the *CEF-JL* moderate case with emissions limits, the wholesale price index for fuel and power (WPI-Fuel and Power) is projected to rise above the case without emissions limits by 12.3 percent in 2007, the first target year for emissions reductions (Table 33). After 2010, the relative increase in this index is projected to decline to 9.9 percent in 2020. Similar to the impacts on the reference and advanced technology cases, the higher electricity and natural gas prices projected for the *CEF-JL* moderate case with emissions limits, compared to the same case without limits, initially affect only the energy portion of the consumer price index (CPI). The higher projected energy prices are expected to be accompanied by general price effects as they are incorporated in the prices of other goods and services. In the *CEF-JL* moderate case with limits, the level of the CPI is projected to be about 0.5 percent above the case without limits by 2007, but the impact on the CPI is expected to be eliminated by 2020.

Imposing emissions limits on the *CEF-JL* moderate case is expected to raise the unemployment rate in 2007 by 0.4 percentage points. Along with the rise in inflation and unemployment, real output of the economy is projected to decline. Real GDP is projected to fall by 0.8 percent relative to the *CEF-JL* moderate case without emissions limits in 2007, and employment in non-agricultural establishments is projected to decline by one million jobs. Similarly, real disposable income is expected to be lower by 0.9 percent.

Table 33. Macroeconomic Impacts of Emissions Limits in the *CEF-JL* Moderate and Advanced Cases, 2007, 2010, and 2020

Projections	2007	2010	2020
Wholesale Price for Fuel and Power (Percent Change From Case Without Limits)			
CEF-JL Moderate Case.	12.3	12.1	9.9
CEF-JL Advanced Case	6.9	5.8	3.1
Real Gross Domestic Product (Percent Change From Case Without Limits)			
CEF-JL Moderate Case.	-0.8	-0.2	0.0
CEF-JL Advanced Case	-0.4	-0.1	0.0
Consumer Price Index (Percent Change From Case Without Limits)			
CEF-JL Moderate Case.	0.5	0.3	0.0
CEF-JL Advanced Case	0.2	0.1	0.0
Unemployment Rate (Change From Case Without Limits)			
CEF-JL Moderate Case.	0.4	0.1	0.0
CEF-JL Advanced Case	0.2	0.0	0.0
Disposable Income (Percent Change From Case Without Limits)			
CEF-JL Moderate Case.	-0.9	-0.4	-0.2
CEF-JL Advanced Case	-0.4	-0.1	0.0
Nonagricultural Employment (Million Jobs, Change From Case Without Limits)			
CEF-JL Moderate Case.	-1.0	-0.4	-0.1
CEF-JL Advanced Case	-0.4	-0.1	0.0

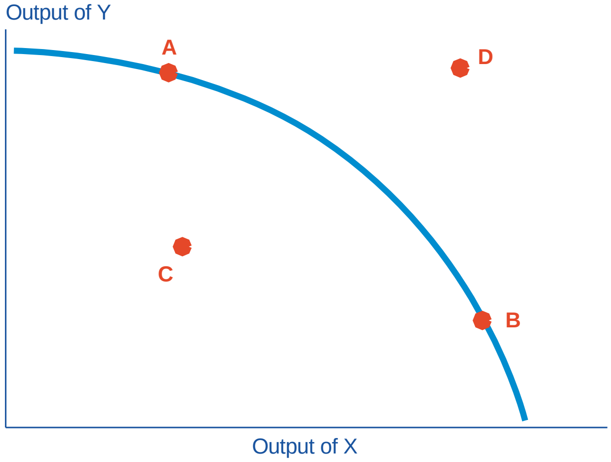
Note: All changes have been rounded to one decimal point.
Source: Simulations of the DRI Macroeconomic Model of the U.S. Economy based on National Energy Modeling System, runs SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

Production Possibilities and the U.S. Macroeconomy

A key finding of the *CEF* study was that "there are large-scale market and / or organizational failures, in addition to potentially substantial transaction costs, that prevent consumers and firms from obtaining many energy services at least cost." Moreover, "interpreted in a macroeconomic context, the . . . economy is not on its aggregate production-possibilities frontier."[a]

The production possibilities curve describes the alternative combinations of final goods and services that can be produced in a given time period with all available resources and technologies (see figure below).[b] Points on the curve (points A and B in the figure) represent the maximum level of output that can be produced with a given set of inputs and technology. However, there are multiple ways in which these inputs can be combined to produce any given set of products or services. Movement along the curve introduces another concept, opportunity cost. The opportunity cost reflects a tradeoff in the production of the economy, i.e. to produce more of a product, given a fixed set of inputs, the economy must produce less of something else, or a combination of other goods and services. Points inside the curve (point C) mean that the economy is not fully utilizing its resources and that more goods and services can be produced from the given set of inputs. Points along the curve are said to be "efficient" in the use of a given set of inputs and technologies, while points inside the curve are "inefficient." Production outside of the curve (point D) is not attainable given current resources and technology.

Production Possibilities Curve



As Appendix E-4 of the *CEF* study stated, ". . . many of the criticisms of studies like the CEF are a disagreement with the extent to which the economy is inside its aggregate production frontier, the effectiveness of policies to overcome this situation, or both." The debate also relates to movements along the curve which represent the opportunity cost of changing the mix of goods and services in the economy. The crucial assumption underlying the *CEF* study was that the economy is not currently on its production possibility curve, i.e., the economy is not using its resource base efficiently. Moreover, the study assumed that a least-cost technology modeling approach can yield a measure of the energy cost savings which permits the economy to move outward to the production possibilities curve frontier. However, to do so requires overcoming "large-scale market and / or organizational failures, in addition to potential substantial transaction costs, that prevent consumers and firms from obtaining many energy services at least cost."

Therefore, by assumption, *CEF* presumed that the economy is operating at a position which is not on the stylized "production possibilities curve" and that overcoming market failures in the use of energy can both make the economy more energy efficient (to the position defined as the moderate case) and actually increase GDP at the same time. This assumption was flawed by *CEF* assumptions that energy markets currently are not behaving efficiently and that any of the market barriers that may exist are, in fact, market failures instead, as discussed below. The distinction is important, because as Henry Jacoby points out, "The key difference between market barriers and market failures is that correcting failures may sometimes produce a net benefit, whereas overcoming barriers always involves cost."[c]

However, as discussed in presenting the energy market assessment in this study, many of the presumed "market failures" are actually rational, efficient decisions on the part of consumers given current technology, expected prices for energy and other goods and services, and the value they place on their time to evaluate options. Consumer preferences for certain attributes of energy-consuming equipment, for example, larger cars or houses with increasing use of miscellaneous electric appliances, are consistent with making

(continued on page 81)

[a]Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL / CON-476 and LBNL-44029 (Oak Ridge National Laboratory, Oak Ridge, TN, and Lawrence Berkeley National Laboratory, Berkeley, CA, November 2000), Appendix E-4, "Estimating Bounds on the Macroeconomic Effects of the CEF Policy Scenarios," web site www.ornl.gov / ORNL / Energy_Eff / CEF-E4.pdf.

[b]B.R. Schiller, *The Macro Economy Today*, Eighth Edition (New York, NY: McGraw-Hill, 2000), pp. 7-10.

[c]H. Jacoby, "The Uses and Misuses of Technology Development as a Component of Climate Change Policy," presentation to the America Council for Capital Formation, Center for Policy Research (October 1998).

Production Possibilities and the U.S. Macroeconomy (Continued)

efficient household decisions. These may represent "barriers" to the adoption of certain energy technologies, but this does not constitute a market failure which prevents the economy from operating on the efficient portion of the production-possibilities curve.[d] Also, many of the programs which are promoted to overcome a market failure overstate the case. Incorrect information can indeed lead consumers to make wrong choices, but benefits of information programs and voluntary initiatives are difficult to quantify.

It is also appropriate to consider a movement along the production-possibility curve to a position that society may deem to be more desirable, for example, one with a lower level of emissions. This is done most often through a change in energy prices vis-a-vis other goods and services, which changes the mix of production and consumption in the economy. However, the carbon trading fee that attains this mix is dependent on the location of the economy relative to the production-possibilities curve. If one presumes that the economy has an alternative reference case with lower emissions, the task of attaining a lower emissions target is lessened. By making this assumption, the *CEF* authors effectively lowered the projected cost of meeting the more stringent emissions targets.

[d]For a good discussion of the distinction between market failures and market barriers, see H. Jacoby, "The Uses and Misuses of Technology Development as a Component of Climate Change Policy," presented to the American Council for Capital Formation, Center for Policy Research (October 1998).

As the economy adjusts to higher energy prices, inflation begins to subside in the forecasts after 2007. At the same time, the economy begins to return to its long-run growth path. By 2020, in the *CEF-JL* moderate case with emissions limits, both the unemployment rate and real GDP are projected to return to the same levels as in the case without emissions limits.

Macroeconomic Impacts of Emissions Limits on the *CEF-JL* Advanced Case

The *CEF-JL* advanced case has lower energy consumption and emissions than the *CEF-JL* moderate case, lowering the cost of attaining emissions limits. Imposing emissions limits on the *CEF-JL* advanced case is projected to raise the WPI-Fuel and Power by 6.9 percent above the level in the same case without emissions limits, compared to a 12.3-percent increase in WPI-Fuel and Power in the *CEF-JL* moderate case. By 2020, the projected increase in the WPI-Fuel and Power by imposing emissions limits in the *CEF-JL* advanced case is only 3.1 percent, compared to a projected 9.9-percent increase caused by imposing the limits on the *CEF-JL* moderate case.

The smaller impact on energy prices in the *CEF-JL* advanced case when emissions limits are imposed, compared to the *CEF-JL* moderate case, results in a smaller impact on prices, employment, and real output in the aggregate economy. The peak impact on the CPI due to the imposition of emissions limits, also in 2007, is projected to be 0.2 percent, compared to 0.5 percent in the *CEF-JL* moderate case. By 2020, in the *CEF-JL* advanced case with emissions limits, both CPI and real GDP return to the same levels as in the case without emissions limits. The imposition of emissions limits is less costly to the aggregate economy as it transitions to a new equilibrium position toward the end of the forecast period. Similar to comparing the impacts of emissions limits between the reference and advanced technology cases, the different levels of energy consumption and emissions in the *CEF-JL* moderate and advanced cases have a significant effect on the magnitude and profile of the impacts on the economy of attaining emissions limits.

Appendix A

Letter from the U.S. Senate Committee on Environment and Public Works

JAMES M. JEFFORDS
VERMONT

COMMITTEES:
HEALTH, EDUCATION, LABOR, AND PENSIONS
CHAIRMAN

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Aging
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United States Senate
WASHINGTON, DC 20510-4503

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May 17, 2001

Lawrence Pettis
Acting Administrator Energy Information Administration
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Acting Administrator Pettis:

We are writing to request that the Energy Information Administration (EIA) analyze the potential costs and benefits of different approaches to multi-pollutant strategies that reduce air pollutants from the nation's electric power plants. In particular, we seek to understand the complementary role of technology and market-based programs as they might lower costs and increase the benefits associated with multi-pollutant strategies. A similar request is being forwarded to the Environmental Protection Agency (EPA). It is our understanding that EIA has the ability to conduct such analysis, including the use of both electricity sector and economy-wide energy models. Such an analysis, utilizing both sectoral and all-economy models, will help inform the Members of Congress about the full costs and benefits of reducing the nation's air pollutants.

We have two primary concerns in making this request, both stemming from the December 2000 release of an EIA report, *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide* (SR/OIAF/2000-05). First, EIA's analysis appears to unnecessarily limit the market and technology opportunities that might significantly affect the costs and benefits of emission reductions. In particular, the potential contributions of demand-side efficiency, gas-fired cogeneration and of renewable energy sources appear to be inadequately represented in the analysis, and the learning curve, economy of scale, and other effects of accelerated penetration of these options on their costs and performance appear to be inadequately treated. Moreover, the report did not reflect any of the health or environmental benefits associated with emission reductions.

Second, just prior to the release of the December report, a new assessment by the Department of Energy's national laboratories was completed that describes a broad number of technology and market-based opportunities that might positively affect almost any multi-pollutant strategy. The report by the national laboratories, *Scenarios for a Clean Energy Future*, was released in November 2000. Unfortunately, the findings of the national laboratories were not included in any aspect of the December study. With these important omissions in the report, we believe it would be appropriate to reconsider the analysis with a more complete and updated assessment.

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We therefore request that EIA analyze the cost and benefits, including all sectors of the economy and impacts on both the supply and demand side of the equation, of the following multi-pollutant emission control scenarios for the nation's electricity generators. Where feasible, this should include power plants both within the conventionally defined electric utility sector as well as electricity generated by industrial cogenerators and other independent power producers. To the maximum extent possible, we ask that you coordinate your efforts with EPA so that we might obtain maximum benefit of this review. Please provide results through 2020, in periods of five years or less, using the EIA's Annual Energy Outlook 2001 (AEO2001) as the baseline.

- Scenario A: Assume standard technology characteristics as defined in AEO2001. Further assume a start date of 2002. By 2007 reduce NO_x emissions 75 percent below 1997 levels, reduce SO_2 emissions to 75 percent below full implementation of the Phase II requirements under title IV, reduce mercury emissions 90 percent below 1999 levels, and reduce CO_2 emissions to 1990 levels.

- Scenario B: Continuing a 2002 start date, but assuming the advanced technology assumptions of both the supply and demand-side perspectives that are referenced in AEO2001, by 2007 reduce NO_x emissions 75 percent below 1997 levels, reduce SO_2 emissions to 75 percent below full implementation of the Phase II requirements under title IV, reduce mercury emissions 90 percent below 1999 levels, and reduce CO_2 emissions to 1990 levels.

- Scenario C: Continuing a 2002 start date, but assuming the moderate supply and demand-side policy scenario of the Clean Energy Futures study, by 2007 reduce NO_x emissions 75 percent below 1997 levels, reduce SO_2 emissions to 75 percent below full implementation of the Phase II requirements under title IV, reduce mercury emissions 90 percent below 1999 levels, and reduce CO_2 emissions to 1990 levels.

- Scenario D: Continuing a 2002 start date, but assuming the advanced supply and demand-side policy scenario of the Clean Energy Futures study, by 2007 reduce NO_x emissions 75 percent below 1997 levels, reduce SO_2 emissions to 75 percent below full implementation of the Phase II requirements under title IV, reduce mercury emissions 90 percent below 1999 levels, and reduce CO_2 emissions to 1990 levels.

In comparing scenarios A to D, the impact of the expanded methodology of this exercise relative to the previous EIA work on multi-pollutant effects should be clarified.

Given that the Senate will be debating national energy policy legislation in the coming months, including issues impacting air quality, we ask that the requested information be made available by July 1, 2001. In addition, we request a briefing of your results prior to the release of any written report. If you have any questions about this request, please call Kathryn Parker with Senator Jeffords at 224-3977 or Tim Profeta with Senator Lieberman at 224-5016. Thank you for your attention to this request.

Sincerely,

Jim Jeffords

Senator James M. Jeffords

J Lieberman

Senator Joseph I. Lieberman

Appendix B

Industrial Sector Technology Assumptions

Table B1. Nonmanufacturing Industry Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
All Processes	All Fuels	-0.001	-0.002	0.9	-0.002	-0.004

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B2. Nonmanufacturing Industry Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
All Processes	All Fuels	-0.0015	-0.002	0.9	-0.003	-0.004

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B3. Food Industry Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
All Processes	All Fuels	-0.0044	-0.0072	0.9	-0.0049	-0.0145

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B4. Food Industry Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
All Processes	All Fuels	-0.0058	-0.0072	0.9	-0.0097	-0.0145

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B5. Pulp and Paper Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
Wood Preparation	Electricity	-0.0037	-0.0043	0.84	-0.0004	-0.0086
Waste Pulp	Electricity	-0.0025	-0.0036	0.93	-0.002	-0.0073
Mechanical Pulp	Electricity	-0.0039	-0.0041	0.84	-0.0009	-0.0082
Semi-Chemical	Electricity	-0.0054	-0.0077	0.73	-0.0019	-0.0153
Kraft Pulp	Electricity	-0.0093	-0.0143	0.73	-0.0082	-0.0287
	Natural Gas	-0.0093	-0.0143	0.73	-0.0082	-0.0287
	Residual	-0.0093	-0.0143	0.73	-0.0082	-0.0287
	Distillate	-0.0093	-0.0143	0.73	-0.0082	-0.0287
	LPG	-0.0093	-0.0143	0.73	-0.0082	-0.0287
	Coal	-0.0093	-0.0143	0.73	-0.0082	-0.0287
Bleaching	Electric	-0.005	-0.0098	0.75	-0.0039	-0.0197
Papermaking	Electric	-0.0104	-0.0166	0.75	-0.0122	-0.0332
	Natural Gas	-0.0104	-0.0166	0.75	-0.0122	-0.0332
	Residual	-0.0104	-0.0166	0.75	-0.0122	-0.0332
	Distillate	-0.0104	-0.0166	0.75	-0.0122	-0.0332
	LPG	-0.0104	-0.0166	0.75	-0.0122	-0.0332
	Coal	-0.0104	-0.0166	0.75	-0.0122	-0.0332

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B6. Pulp and Paper Technology Possibility Curves Derived from *CEF*

Process	Fuel[a]	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
Wood Preparation	Electricity	-0.00135	-0.0027	0.84	-0.0008	-0.001
Waste Pulp	Electricity	-0.0004	-0.0007	0.93	-0.004	-0.005
Mech Pulp	Electricity	-0.0012	-0.0024	0.84	-0.005	-0.011
Semi-Chemical	Electricity	-0.0028	-0.0049	0.73	-0.0004	-0.0004
Kraft Pulp	Electricity	-0.0028	-0.0049	0.73	-0.0025	-0.0049
	Natural Gas	-0.0029	-0.0057	0.73	-0.006	-0.0122
	Residual	-0.0029	-0.0057	0.73	-0.0062	-0.0124
	Distillate	-0.0029	-0.0057	0.73	-0.0062	-0.0124
	LPG	-0.0029	-0.0057	0.73	-0.0062	-0.0124
	Coal	-0.005	-0.007	0.73	-0.0075	-0.015
Bleaching	Electric	-0.0054	-0.0085	0.75	-0.0006	-0.0006
Papermaking	Electric	-0.0032	-0.0049	0.75	-0.002	0.0015
	Natural Gas	-0.0032	-0.0049	0.75	-0.002	-0.002
	Residual	-0.0032	-0.0049	0.75	-0.002	-0.002
	Distillate	-0.0032	-0.0049	0.75	-0.002	-0.002
	LPG	-0.0032	-0.0049	0.75	-0.002	-0.002
	Coal	-0.0032	-0.0049	0.75	-0.002	-0.002

[a]In some processes, a particular fuel was not represented in the CEF. In such situations, a TPC from the same process was applied.

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B7. Bulk Chemical Industry Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
Heat and Power	All Fuels	-0.0044	-0.0056	0.9	-0.0049	-0.0113
Feedstocks	All Fuels	-0.001	-0.002	0.9	-0.001	-0.002

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B8. Bulk Chemical Industry Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
Heat and Power	All Fuels	-0.005	-0.008	0.9	-0.007	-0.009
Feedstocks	All Fuels	-0.005	-0.008	0.9	-0.007	-0.009

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B9. Glass Industry Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
Batch Preparation Virgin Glass	Electricity	-0.0025	-0.0026	0.882	0	-0.0052
Batch Preparation Recycled Glass	Electricity	-0.0025	-0.0026	0.882	0	-0.0052
Melting/Refining Virgin Glass	Electricity	-0.0094	-0.0165	0.85	-0.016	-0.033
	Fuels	-0.0094	-0.0165	0.85	-0.016	-0.033
Melting/Refining Recycled Glass	Electricity	-0.0094	-0.0153	0.85	-0.016	-0.0306
	Fuels	-0.0094	-0.0153	0.85	-0.016	-0.0306
Forming	Electricity	-0.0035	-0.0054	0.818	-0.004	-0.0108
	Fuels	-0.0035	-0.0054	0.818	-0.004	-0.0108
Post-Forming	Electricity	-0.0053	-0.006	0.78	-0.0011	-0.012
	Fuels	-0.0053	-0.006	0.78	-0.0011	-0.012

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B10. Glass Industry Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
Batch Preparation Virgin Glass	Electricity	-0.001	-0.001	0.882	0	0
Batch Preparation Recycled Glass	Electricity	-0.001	-0.001	0.882	0	0
Melting/Refining Virgin Glass	Electricity	-0.00575	-0.0115	0.85	-0.0115	-0.023
	Fuels	-0.0068	-0.0136	0.85	-0.0136	-0.0272
Melting/Refining Recycled Glass	Electricity	-0.00575	-0.0115	0.85	-0.0115	-0.023
	Fuels	-0.0068	-0.0136	0.85	-0.0136	-0.0272
Forming	Electricity	-0.0014	-0.0014	0.818	-0.0015	-0.003
	Fuels	-0.0025	-0.0025	0.818	-0.00205	-0.0041
Post-Forming	Electricity	-0.0021	-0.0021	0.78	-0.0008	-0.0015
	Fuels	-0.0037	-0.0037	0.78	-0.0009	-0.0018

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B11. Cement Industry Technology Possibility Curves from *AEO2001*

		Existing Equipment		New Equipment		
Process	Fuel	Reference	High Technology	REI 1994	Reference	High Technology
Grinding	Electricity	-0.0041	-0.0088	0.813	0	-0.0177
Dry Process	Electricity	-0.0031	-0.0115	0.79	-0.0031	-0.023
	Natural Gas	-0.0078	-0.0115	0.79	-0.0077	-0.023
	Distillate	-0.0078	-0.0115	0.79	-0.0077	-0.023
	Steam Coal	-0.0078	-0.0115	0.79	-0.0077	-0.023
	Other	-0.0078	-0.0115	0.79	-0.0077	-0.023
Wet Process	Electricity	-0.0025	0	NA	NA	NA
	Natural Gas	-0.0025	0.0006	NA	NA	NA
	Distillate	-0.0025	-0.0045	NA	NA	NA
	Steam Coal	-0.0025	-0.0057	NA	NA	NA
	Other	-0.0025	-0.0057	NA	NA	NA

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B12. Cement Industry Technology Possibility Curves Derived from *CEF*

		Existing Equipment		New Equipment		
Process	Fuel	Moderate	Advanced	REI 1994	Moderate	Advanced
Grinding	Electricity	-0.0032	-0.0032	0.813	-0.0027	-0.0049
Dry Process	Electricity	0	0	0.79	0	-0.0049
	Natural Gas	0.0002	-0.0035	0.79	0.0039	-0.0027
	Distillate	-0.0032	-0.0045	0.79	-0.0032	-0.0045
	Steam Coal	-0.0032	-0.0042	0.79	-0.00323	-0.0042
	Other	-0.0033	-0.043	0.79	-0.0033	-0.0043
Wet Process	Electricity	0	0	NA	NA	NA
	Natural Gas	-0.0023	0.0006	NA	NA	NA
	Distillate	-0.0045	-0.0045	NA	NA	NA
	Steam Coal	-0.0051	-0.0057	NA	NA	NA
	Other	-0.0051	-0.0057	NA	NA	NA

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B13. Steel Industry Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
Cold Rolling	Electricity	-0.0101	-0.022	0.84	-0.0162	-0.044
	Fuels	-0.0101	-0.022	0.84	-0.0162	-0.044
Hot Rolling	Electricity	-0.0152	-0.0532	0.5	-0.0104	-0.1065
	Fuels	-0.0152	-0.0532	0.5	-0.0104	-0.1065
Ingot	Electricity	0	0	NA	NA	NA
	Fuels	0	0	NA	NA	NA
Continuous Cast	Electricity	0	0	1	0	0
	Fuels	0	0	1	0	0
Blast Furnace/ Basic Oxygen Furnace	Electricity	-0.0041	-0.0155	1	-0.0086	-0.031
	Natural Gas	0.005	-0.0155	1	0.02	-0.031
	Coke	-0.002	-0.0155	1	-0.004	-0.031
	Steam Coal	-0.0041	-0.0155	1	0.002	-0.031
	Other Fuels	-0.0041	-0.0067	1	-0.0086	-0.031
Electric Arc Furnace	Electricity	-0.0032	-0.0056	0.96	-0.0051	-0.0112
	Fuels	-0.0032	-0.0056	0.96	-0.0051	-0.0112
Coke Plant	Electricity	-0.0039	-0.0078	0.84	-0.0012	-0.0024
	Fuels	-0.0039	-0.0078	0.84	-0.0009	-0.0018

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B14. Steel Industry Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
Cold Rolling	Electricity	-0.0055	-0.0058	0.84	-0.0013	-0.0013
	Fuels	0	-0.0025	0.84	-0.015	-0.015
Hot Rolling	Electricity	-0.0002	-0.0002	0.5	-0.0098	-0.0426
	Fuels	-0.0153	-0.0173	0.5	-0.0221	-0.117
Ingot	Electricity	0	0	NA	NA	NA
	Fuels	0	0	NA	NA	NA
Continuous Cast	Electricity	0	0	1	-0.0263	-0.0263
	Fuels	-0.0111	-0.0111	1	-0.011	-0.011
Blast Furnace/ Basic Oxygen Furnace	Electricity	-0.0053	-0.0053	1	-0.0227	0.0086
	Natural Gas	0	0	1	0	0
	Other Fuels	-0.0067	-0.0067	1	-0.0041	0.0006
	Electricity	-0.0086	-0.0102	0.96	-0.0107	-0.0107
	Fuels	0.0056	0.0056	0.96	-0.0054	-0.0054
Electric Arc Furnace	Electricity	0	0	0.84	-0.0401	-0.1215
	Fuels	-0.0004	-0.0004	0.84	-0.0026	-0.2731

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B15. Aluminum Industry Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
All Processes	Electricity	-0.005	-0.0087	0.76	-0.005	-0.0174
	Fuels	-0.005	-0.0087	0.76	-0.005	-0.0174

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B16. Aluminum Industry Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
All Processes	Electricity	-0.0074	-0.012	0.76	-0.0025	-0.0038
	Fuels	-0.004	-0.0058	0.76	-0.0035	-0.0048

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B17. Metal-Based Durables Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
Refrigeration	Electricity	-0.0055	-0.0043	0.9	-0.0052	-0.0086
Machine Drive	Electricity	-0.0021	-0.0024	0.9	-0.0049	-0.0049
	Fossil	-0.0044	-0.0067	0.9	-0.0049	-0.0135
Electrochemical	Electricity	-0.0008	-0.0041	0.9	-0.0046	-0.0082
Other	Electricity	-0.0008	-0.0049	0.9	-0.0046	-0.0098
	Fossil	-0.0044	-0.0067	0.9	-0.0049	-0.0135
Heating	Electricity	-0.0044	-0.0121	0.9	-0.0049	-0.0242
	Fossil	-0.0044	-0.0067	0.9	-0.0049	-0.0135

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B18. Metal-Based Durables Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
Refrigeration	Electricity	-0.0083	-0.011	0.9	-0.0078	-0.0104
Machine Drive	Electricity	-0.0032	-0.0042	0.9	-0.0074	-0.0098
	Fossil	-0.0066	-0.0088	0.9	-0.0074	-0.0098
Electrochemical	Electricity	-0.0012	-0.0041	0.9	-0.0069	-0.0082
Other	Electricity	-0.0012	-0.0049	0.9	-0.0069	-0.0098
	Fossil	-0.0066	-0.0067	0.9	-0.0074	-0.0135
Heating	Electricity	-0.0066	-0.0088	0.9	-0.0074	-0.0098
	Fossil	-0.0066	-0.0067	0.9	-0.0074	-0.0098

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B19. Other Manufacturing Technology Possibility Curves from *AEO2001*

Process	Fuel	Existing Equipment		New Equipment		
		Reference	High Technology	REI 1994	Reference	High Technology
Refrigeration	Electricity	-0.0055	-0.0043	0.9	-0.0052	-0.0086
Machine Drive	Electricity	-0.0021	-0.0024	0.9	-0.0049	-0.0049
	Fossil	-0.0044	-0.0067	0.9	-0.0049	-0.0135
Electrochemical	Electricity	-0.0008	-0.0041	0.9	-0.0046	-0.0082
Other	Electricity	-0.0008	-0.0049	0.9	-0.0046	-0.0098
	Fossil	-0.0044	-0.0067	0.9	-0.0049	-0.0135
Heating	Electricity	-0.0044	-0.0121	0.9	-0.0049	-0.0242
	Fossil	-0.0044	-0.0067	0.9	-0.0049	-0.0135

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table B20. Other Manufacturing Technology Possibility Curves Derived from *CEF*

Process	Fuel	Existing Equipment		New Equipment		
		Moderate	Advanced	REI 1994	Moderate	Advanced
Refrigeration	Electricity	-0.0083	-0.011	0.9	-0.0078	-0.0104
Machine Drive	Electricity	-0.0032	-0.0042	0.9	-0.0074	-0.0098
	Fossil	-0.0066	-0.0088	0.9	-0.0074	-0.0098
Electrochemical	Electricity	-0.0012	-0.0041	0.9	-0.0069	-0.0082
Other	Electricity	-0.0012	-0.0049	0.9	-0.0069	-0.0098
	Fossil	-0.0066	-0.0067	0.9	-0.0074	-0.0135
Heating	Electricity	-0.0066	-0.0088	0.9	-0.0074	-0.0098
	Fossil	-0.0066	-0.0067	0.9	-0.0074	-0.0098

REI 1994 = Relative Energy Intensity of new equipment in 1994 compared with the average existing intensity. Note that in most cases, the energy intensity of new 1994 equipment is less than that of existing equipment. Hence, the TPC for new equipment occasionally is not as rapid as for existing equipment.

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Appendix C

Tables for the Reference and Advanced Technology Cases

Table C1. Total Energy Supply and Disposition Summary
(Quadrillion Btu per Year, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Production									
Crude Oil and Lease Condensate	12.45	12.04	12.00	12.30	12.27	11.23	11.19	11.73	11.71
Natural Gas Plant Liquids	2.62	3.11	3.18	3.05	3.14	3.36	3.54	3.22	3.57
Dry Natural Gas	19.16	21.88	22.41	21.46	22.12	23.97	25.27	22.98	25.52
Coal	23.06	25.43	21.54	25.24	21.68	26.49	16.81	26.08	17.24
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.69	7.91	7.95	7.95
Renewable Energy[1]	6.52	7.09	8.60	7.44	8.30	7.86	9.58	8.23	9.77
Other[2]	1.65	0.35	0.35	0.34	0.58	0.30	0.30	0.52	0.29
Total	**73.26**	**77.79**	**75.99**	**77.74**	**75.99**	**80.90**	**74.59**	**80.70**	**76.04**
Imports									
Crude Oil[3]	18.96	21.42	21.36	21.25	21.25	22.49	22.44	22.05	22.07
Petroleum Products[4]	4.14	6.11	5.78	5.47	5.04	8.52	8.20	6.71	6.52
Natural Gas	3.63	5.14	5.10	5.09	5.00	5.55	6.88	5.33	5.69
Other Imports[5]	0.64	1.11	1.01	1.08	0.99	0.96	0.88	0.89	0.81
Total	**27.37**	**33.78**	**33.26**	**32.89**	**32.28**	**37.52**	**38.40**	**34.98**	**35.09**
Exports									
Petroleum[6]	1.98	1.73	1.77	1.77	1.80	1.73	1.71	1.79	1.79
Natural Gas	0.17	0.33	0.33	0.33	0.33	0.43	0.12	0.43	0.43
Coal	1.48	1.51	1.52	1.51	1.52	1.45	1.50	1.46	1.52
Total	**3.62**	**3.56**	**3.61**	**3.61**	**3.64**	**3.61**	**3.32**	**3.68**	**3.74**
Discrepancy[7]	**0.67**	**0.44**	**0.42**	**0.44**	**0.55**	**0.06**	**0.05**	**0.27**	**0.07**
Consumption									
Petroleum Products[8]	37.92	41.21	40.83	40.55	40.28	44.30	44.10	42.35	42.44
Natural Gas	22.32	26.38	26.87	25.92	26.48	28.94	31.85	27.72	30.59
Coal	21.40	24.37	20.40	24.15	20.49	25.57	15.66	25.11	16.05
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.69	7.91	7.95	7.95
Renewable Energy[1]	6.53	7.10	8.61	7.45	8.30	7.87	9.58	8.24	9.78
Other[9]	0.35	0.61	0.61	0.61	0.61	0.38	0.51	0.38	0.51
Total	**96.33**	**107.56**	**105.22**	**106.59**	**104.07**	**114.74**	**109.61**	**111.74**	**107.32**
Net Imports - Petroleum	**21.12**	**25.80**	**25.38**	**24.95**	**24.50**	**29.28**	**28.93**	**26.97**	**26.80**
Prices (1999 dollars per unit)									
World Oil Price (dollars per barrel)[10]	17.22	20.83	20.83	20.83	20.83	21.37	21.37	21.37	21.37
Gas Wellhead Price (dollars per Mcf)[11]	2.08	2.99	3.01	2.86	2.87	2.82	3.41	2.39	2.95
Coal Minemouth Price (dollars per ton)	17.13	15.22	14.47	14.30	13.77	14.19	14.63	12.73	13.40
Average Electric Price (cents per Kwh)	6.7	6.4	7.3	6.3	7.0	6.1	8.0	5.9	7.4

[1]Includes grid-connected electricity from conventional hydroelectric; wood and wood waste; landfill gas; municipal solid waste; other biomass; wind; photovoltaic and solar thermal sources; non-electric energy from renewable sources, such as active and passive solar systems, and wood; and both the ethanol and gasoline components of E85, but not the ethanol components of blends less than 85 percent. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table C18 for selected nonmarketed residential and commercial renewable energy.
[2]Includes liquid hydrogen, methanol, supplemental natural gas, and some domestic inputs to refineries.
[3]Includes imports of crude oil for the Strategic Petroleum Reserve.
[4]Includes imports of finished petroleum products, imports of unfinished oils, alcohols, ethers, and blending components.
[5]Includes coal, coal coke (net), and electricity (net).
[6]Includes crude oil and petroleum products.
[7]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[8]Includes natural gas plant liquids, crude oil consumed as a fuel, and nonpetroleum based liquids for blending, such as ethanol.
[9]Includes net electricity imports, methanol, and liquid hydrogen.
[10]Average refiner acquisition cost for imported crude oil.
[11]Represents lower 48 onshore and offshore supplies.
Btu = British thermal unit.
Mcf = Thousand cubic feet.
Kwh = Kilowatthour.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 natural gas values: Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). 1999 petroleum values: EIA, *Petroleum Supply Annual 1999,* DOE/EIA-0340(99/1) (Washington, DC, June 2000). Other 1999 values: EIA, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000) and EIA, *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
11.08	11.25	11.75	11.93	11.06	11.35	11.62	11.94
3.76	3.94	3.56	3.91	4.14	4.33	3.87	4.25
27.19	28.50	25.62	28.28	30.10	31.46	28.05	30.91
26.84	15.46	26.19	16.26	27.10	14.43	25.91	15.35
6.98	7.68	7.84	7.91	6.51	7.15	7.18	7.69
8.16	9.97	8.66	10.19	8.37	10.44	9.06	10.63
0.31	0.31	0.53	0.29	0.33	0.33	0.61	0.38
84.31	**77.12**	**84.14**	**78.78**	**87.61**	**79.48**	**86.31**	**81.14**
25.27	24.82	23.40	23.01	25.91	25.74	24.30	24.03
8.67	8.58	6.69	6.65	10.70	10.25	7.26	7.09
6.11	7.71	5.61	6.15	6.55	8.16	5.88	6.38
0.88	0.77	0.79	0.68	0.96	0.81	0.83	0.69
40.93	**41.88**	**36.49**	**36.48**	**44.11**	**44.96**	**38.28**	**38.18**
1.73	1.73	1.83	1.86	1.82	1.79	1.84	1.91
0.53	0.12	0.53	0.53	0.63	0.12	0.63	0.63
1.40	1.52	1.44	1.52	1.41	1.59	1.41	1.56
3.67	**3.36**	**3.80**	**3.92**	**3.87**	**3.50**	**3.89**	**4.10**
0.23	**0.19**	**0.30**	**0.02**	**0.18**	**0.08**	**0.28**	**0.05**
47.33	47.19	43.98	44.07	50.36	50.30	45.71	45.85
32.60	35.92	30.55	33.73	35.88	39.32	33.16	36.49
26.03	14.32	25.25	15.05	26.30	13.27	25.05	14.13
6.98	7.68	7.84	7.91	6.51	7.15	7.18	7.69
8.17	9.98	8.67	10.20	8.38	10.45	9.08	10.64
0.24	0.36	0.24	0.37	0.25	0.38	0.25	0.38
121.34	**115.45**	**116.53**	**111.33**	**127.68**	**120.86**	**120.42**	**115.18**
32.21	**31.67**	**28.26**	**27.80**	**34.78**	**34.20**	**29.72**	**29.21**
21.89	21.89	21.89	21.89	22.41	22.41	22.41	22.41
2.92	3.35	2.30	2.73	3.10	3.72	2.20	2.60
13.40	13.58	11.63	12.01	12.93	12.61	10.76	10.97
6.1	8.0	5.7	7.1	6.1	8.1	5.5	6.7

Table C2. Energy Consumption by Sector and Source
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Energy Consumption									
Residential									
Distillate Fuel	0.86	0.87	0.87	0.84	0.84	0.80	0.81	0.75	0.75
Kerosene	0.10	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
Liquefied Petroleum Gas	0.46	0.46	0.46	0.44	0.45	0.43	0.43	0.40	0.40
Petroleum Subtotal	1.42	1.41	1.41	1.37	1.37	1.30	1.31	1.21	1.22
Natural Gas	4.88	5.55	5.56	5.41	5.42	5.54	5.46	5.28	5.20
Coal	0.04	0.05	0.05	0.04	0.04	0.05	0.05	0.05	0.05
Renewable Energy[1]	0.41	0.42	0.42	0.40	0.40	0.42	0.42	0.39	0.38
Electricity	3.91	4.56	4.44	4.54	4.43	4.91	4.58	4.85	4.58
Delivered Energy	**10.66**	**11.99**	**11.87**	**11.76**	**11.66**	**12.22**	**11.83**	**11.77**	**11.43**
Electricity Related Losses	8.44	9.66	8.96	9.67	8.87	10.00	8.54	9.87	8.52
Total	**19.10**	**21.65**	**20.83**	**21.43**	**20.54**	**22.22**	**20.36**	**21.65**	**19.95**
Commercial									
Distillate Fuel	0.36	0.37	0.37	0.37	0.37	0.38	0.39	0.37	0.37
Residual Fuel	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Kerosene	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Liquefied Petroleum Gas	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Motor Gasoline[2]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Petroleum Subtotal	0.60	0.61	0.61	0.61	0.61	0.62	0.63	0.61	0.61
Natural Gas	3.14	3.99	3.99	4.00	4.00	4.19	4.12	4.22	4.15
Coal	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Renewable Energy[3]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Electricity	3.66	4.40	4.28	4.38	4.27	4.92	4.63	4.85	4.62
Delivered Energy	**7.55**	**9.15**	**9.02**	**9.14**	**9.03**	**9.88**	**9.53**	**9.84**	**9.54**
Electricity Related Losses	7.91	9.33	8.64	9.32	8.55	10.02	8.62	9.87	8.60
Total	**15.46**	**18.48**	**17.66**	**18.45**	**17.58**	**19.90**	**18.15**	**19.71**	**18.14**
Industrial[4]									
Distillate Fuel	1.13	1.21	1.20	1.20	1.20	1.30	1.29	1.28	1.28
Liquefied Petroleum Gas	2.32	2.44	2.44	2.42	2.42	2.51	2.56	2.47	2.52
Petrochemical Feedstock	1.29	1.36	1.35	1.35	1.35	1.53	1.52	1.52	1.52
Residual Fuel	0.22	0.16	0.16	0.16	0.16	0.25	0.26	0.24	0.25
Motor Gasoline[2]	0.21	0.23	0.23	0.23	0.22	0.25	0.24	0.24	0.24
Other Petroleum[5]	4.29	4.41	4.43	4.37	4.41	4.68	4.72	4.42	4.61
Petroleum Subtotal	9.45	9.81	9.82	9.73	9.76	10.51	10.60	10.17	10.41
Natural Gas[6]	9.80	10.42	10.44	10.35	10.37	11.27	11.34	11.22	11.24
Metallurgical Coal	0.75	0.67	0.67	0.66	0.66	0.61	0.61	0.58	0.58
Steam Coal	1.73	1.80	1.81	1.79	1.80	1.82	1.79	1.79	1.75
Net Coal Coke Imports	0.06	0.11	0.11	0.08	0.08	0.15	0.15	0.09	0.09
Coal Subtotal	2.54	2.59	2.59	2.54	2.54	2.58	2.54	2.46	2.43
Renewable Energy[7]	2.15	2.40	2.40	2.48	2.47	2.63	2.62	2.81	2.81
Electricity	3.61	3.88	3.78	3.83	3.73	4.16	3.88	4.03	3.79
Delivered Energy	**27.56**	**29.10**	**29.03**	**28.92**	**28.89**	**31.14**	**30.98**	**30.69**	**30.67**
Electricity Related Losses	7.80	8.21	7.64	8.16	7.47	8.47	7.22	8.20	7.05
Total	**35.36**	**37.31**	**36.67**	**37.08**	**36.36**	**39.61**	**38.21**	**38.90**	**37.72**

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
0.78	0.78	0.70	0.70	0.76	0.77	0.66	0.67
0.07	0.07	0.06	0.06	0.07	0.07	0.06	0.06
0.41	0.42	0.38	0.39	0.41	0.42	0.36	0.38
1.26	1.28	1.14	1.15	1.23	1.26	1.08	1.10
5.78	5.73	5.44	5.37	6.08	6.01	5.67	5.60
0.05	0.05	0.04	0.04	0.05	0.05	0.04	0.04
0.43	0.42	0.38	0.37	0.43	0.43	0.38	0.37
5.27	4.92	5.18	4.89	5.69	5.27	5.58	5.30
12.79	**12.40**	**12.18**	**11.83**	**13.48**	**13.01**	**12.75**	**12.41**
10.28	8.64	10.13	8.58	10.65	8.71	10.19	8.63
23.08	**21.04**	**22.31**	**20.41**	**24.14**	**21.72**	**22.94**	**21.04**
0.38	0.39	0.37	0.37	0.37	0.39	0.35	0.36
0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.62	0.64	0.61	0.62	0.62	0.64	0.60	0.61
4.36	4.40	4.42	4.43	4.47	4.67	4.58	4.68
0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
5.35	4.98	5.24	4.96	5.64	5.17	5.52	5.21
10.48	**10.18**	**10.43**	**10.16**	**10.88**	**10.63**	**10.86**	**10.66**
10.43	8.75	10.24	8.70	10.56	8.55	10.08	8.47
20.91	**18.92**	**20.67**	**18.86**	**21.44**	**19.18**	**20.94**	**19.13**
1.39	1.39	1.36	1.35	1.49	1.49	1.43	1.43
2.67	2.72	2.60	2.61	2.85	2.90	2.74	2.80
1.61	1.60	1.59	1.59	1.69	1.69	1.67	1.67
0.26	0.27	0.21	0.24	0.27	0.29	0.21	0.25
0.26	0.26	0.26	0.26	0.28	0.28	0.28	0.28
4.81	4.85	4.51	4.71	5.00	5.10	4.64	4.78
11.01	11.10	10.53	10.77	11.58	11.75	10.97	11.21
12.03	12.32	11.88	12.09	12.71	13.21	12.39	12.78
0.55	0.55	0.52	0.52	0.50	0.50	0.46	0.46
1.84	1.82	1.79	1.77	1.86	1.87	1.78	1.76
0.19	0.19	0.09	0.09	0.22	0.22	0.10	0.10
2.58	2.56	2.40	2.38	2.59	2.59	2.34	2.32
2.85	2.85	3.17	3.17	3.07	3.07	3.55	3.55
4.43	3.98	4.24	3.85	4.76	4.14	4.50	4.02
32.90	**32.80**	**32.22**	**32.26**	**34.72**	**34.76**	**33.76**	**33.88**
8.64	6.99	8.30	6.77	8.91	6.85	8.22	6.54
41.54	**39.79**	**40.52**	**39.03**	**43.63**	**41.61**	**41.98**	**40.42**

Table C2. Energy Consumption by Sector and Source (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Transportation									
Distillate Fuel	5.13	6.25	6.20	6.10	6.06	6.98	6.88	6.57	6.50
Jet Fuel[8]	3.46	3.88	3.87	3.89	3.88	4.49	4.49	4.49	4.49
Motor Gasoline[2]	15.92	17.64	17.62	17.30	17.29	18.94	18.90	17.86	17.87
Residual Fuel	0.74	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Liquefied Petroleum Gas	0.02	0.03	0.03	0.06	0.06	0.04	0.04	0.09	0.09
Other Petroleum[9]	0.26	0.29	0.29	0.29	0.29	0.31	0.31	0.31	0.31
Petroleum Subtotal	25.54	28.95	28.87	28.48	28.43	31.62	31.47	30.16	30.10
Pipeline Fuel Natural Gas	0.66	0.82	0.84	0.81	0.83	0.90	0.96	0.87	0.97
Compressed Natural Gas	0.02	0.05	0.05	0.07	0.07	0.09	0.09	0.13	0.13
Renewable Energy (E85)[10]	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.05	0.05
Methanol (M85)[11]	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	0.06	0.09	0.09	0.07	0.07	0.12	0.12	0.09	0.09
Delivered Energy	**26.28**	**29.94**	**29.88**	**29.47**	**29.44**	**32.77**	**32.67**	**31.30**	**31.34**
Electricity Related Losses	0.13	0.19	0.18	0.16	0.15	0.24	0.22	0.19	0.17
Total	**26.41**	**30.12**	**30.05**	**29.63**	**29.59**	**33.01**	**32.89**	**31.49**	**31.51**
Delivered Energy Consumption for All Sectors									
Distillate Fuel	7.48	8.70	8.65	8.52	8.47	9.46	9.37	8.97	8.90
Kerosene	0.15	0.13	0.13	0.13	0.13	0.12	0.13	0.12	0.12
Jet Fuel[8]	3.46	3.88	3.87	3.89	3.88	4.49	4.49	4.49	4.49
Liquefied Petroleum Gas	2.88	3.02	3.01	3.00	3.01	3.07	3.12	3.05	3.11
Motor Gasoline[2]	16.17	17.90	17.87	17.55	17.55	19.22	19.17	18.13	18.14
Petrochemical Feedstock	1.29	1.36	1.35	1.35	1.35	1.53	1.52	1.52	1.52
Residual Fuel	1.05	1.10	1.10	1.10	1.10	1.20	1.21	1.18	1.19
Other Petroleum[12]	4.53	4.68	4.70	4.64	4.67	4.96	5.00	4.71	4.89
Petroleum Subtotal	37.01	40.77	40.70	40.18	40.16	44.05	44.00	42.15	42.34
Natural Gas[6]	18.50	20.84	20.88	20.65	20.71	21.99	21.96	21.73	21.68
Metallurgical Coal	0.75	0.67	0.67	0.66	0.66	0.61	0.61	0.58	0.58
Steam Coal	1.84	1.92	1.93	1.90	1.91	1.94	1.91	1.90	1.87
Net Coal Coke Imports	0.06	0.11	0.11	0.08	0.08	0.15	0.15	0.09	0.09
Coal Subtotal	2.65	2.70	2.71	2.65	2.66	2.70	2.67	2.58	2.54
Renewable Energy[13]	2.65	2.93	2.93	2.99	2.98	3.17	3.16	3.33	3.32
Methanol (M85)[11]	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	11.24	12.93	12.58	12.82	12.51	14.10	13.21	13.82	13.08
Delivered Energy	**72.05**	**80.17**	**79.80**	**79.29**	**79.02**	**86.01**	**85.01**	**83.61**	**82.98**
Electricity Related Losses	24.28	27.39	25.42	27.30	25.04	28.73	24.60	28.13	24.34
Total	**96.33**	**107.56**	**105.22**	**106.59**	**104.07**	**114.74**	**109.61**	**111.74**	**107.32**
Electric Generators[14]									
Distillate Fuel	0.05	0.06	0.02	0.06	0.02	0.06	0.02	0.05	0.01
Residual Fuel	0.86	0.37	0.11	0.31	0.10	0.20	0.09	0.14	0.08
Petroleum Subtotal	0.91	0.43	0.13	0.37	0.12	0.25	0.10	0.19	0.10
Natural Gas	3.83	5.54	5.99	5.27	5.77	6.96	9.88	6.00	8.91
Steam Coal	18.75	21.67	17.69	21.51	17.83	22.87	12.99	22.53	13.50
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.69	7.91	7.95	7.95
Renewable Energy[15]	3.88	4.17	5.68	4.46	5.32	4.70	6.42	4.91	6.46
Electricity Imports[16]	0.35	0.61	0.61	0.61	0.61	0.37	0.50	0.37	0.50
Total	**35.52**	**40.32**	**38.00**	**40.12**	**37.55**	**42.83**	**37.81**	**41.95**	**37.42**

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
7.61	7.51	6.92	6.84	8.21	8.11	7.33	7.25
5.22	5.21	5.14	5.14	5.96	5.96	5.84	5.84
20.14	20.11	18.16	18.16	21.25	21.20	18.38	18.41
0.86	0.86	0.85	0.85	0.86	0.86	0.85	0.85
0.05	0.05	0.11	0.11	0.06	0.06	0.14	0.14
0.33	0.33	0.33	0.33	0.35	0.35	0.35	0.35
34.20	34.07	31.52	31.44	36.70	36.55	32.90	32.85
1.01	1.06	0.95	1.05	1.10	1.15	1.02	1.13
0.13	0.13	0.18	0.18	0.16	0.15	0.22	0.21
0.04	0.04	0.06	0.06	0.04	0.04	0.07	0.07
0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.15	0.15	0.11	0.11	0.17	0.17	0.12	0.12
35.53	**35.44**	**32.82**	**32.84**	**38.16**	**38.07**	**34.34**	**34.39**
0.28	0.25	0.21	0.19	0.31	0.27	0.23	0.20
35.81	**35.69**	**33.03**	**33.03**	**38.47**	**38.35**	**34.56**	**34.59**
10.15	10.07	9.35	9.27	10.82	10.75	9.78	9.70
0.12	0.12	0.11	0.11	0.12	0.12	0.11	0.11
5.22	5.21	5.14	5.14	5.96	5.96	5.84	5.84
3.23	3.29	3.19	3.21	3.41	3.48	3.34	3.42
20.43	20.40	18.45	18.45	21.56	21.51	18.69	18.71
1.61	1.60	1.59	1.59	1.69	1.69	1.67	1.67
1.21	1.22	1.16	1.19	1.23	1.24	1.16	1.19
5.12	5.16	4.82	5.02	5.33	5.43	4.97	5.11
47.09	47.08	43.80	43.98	50.13	50.19	45.55	45.77
23.30	23.63	22.87	23.12	24.52	25.19	23.88	24.41
0.55	0.55	0.52	0.52	0.50	0.50	0.46	0.46
1.97	1.94	1.90	1.88	1.99	2.00	1.89	1.88
0.19	0.19	0.09	0.09	0.22	0.22	0.10	0.10
2.71	2.68	2.52	2.50	2.71	2.72	2.46	2.44
3.40	3.39	3.69	3.68	3.64	3.63	4.08	4.07
0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.19	14.02	14.77	13.80	16.25	14.74	15.73	14.65
91.70	**90.82**	**87.65**	**87.09**	**97.25**	**96.47**	**91.70**	**91.34**
29.64	24.64	28.89	24.24	30.43	24.38	28.72	23.84
121.34	**115.45**	**116.53**	**111.33**	**127.68**	**120.86**	**120.42**	**115.18**
0.06	0.02	0.05	0.02	0.06	0.02	0.05	0.01
0.18	0.09	0.13	0.08	0.17	0.09	0.11	0.07
0.24	0.11	0.18	0.10	0.23	0.10	0.16	0.09
9.29	12.28	7.68	10.61	11.36	14.13	9.28	12.08
23.33	11.64	22.73	12.55	23.59	10.55	22.59	11.69
6.98	7.68	7.84	7.91	6.51	7.15	7.18	7.69
4.76	6.59	4.98	6.53	4.75	6.82	5.00	6.57
0.23	0.36	0.23	0.36	0.24	0.37	0.24	0.37
44.83	**38.66**	**43.65**	**38.05**	**46.68**	**39.12**	**44.45**	**38.49**

Table C2. Energy Consumption by Sector and Source (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Total Energy Consumption									
Distillate Fuel	7.53	8.77	8.67	8.58	8.49	9.51	9.39	9.02	8.91
Kerosene	0.15	0.13	0.13	0.13	0.13	0.12	0.13	0.12	0.12
Jet Fuel[8]	3.46	3.88	3.87	3.89	3.88	4.49	4.49	4.49	4.49
Liquefied Petroleum Gas	2.88	3.02	3.01	3.00	3.01	3.07	3.12	3.05	3.11
Motor Gasoline[2]	16.17	17.90	17.87	17.55	17.55	19.22	19.17	18.13	18.14
Petrochemical Feedstock	1.29	1.36	1.35	1.35	1.35	1.53	1.52	1.52	1.52
Residual Fuel	1.92	1.48	1.21	1.41	1.19	1.39	1.29	1.32	1.27
Other Petroleum[12]	4.53	4.68	4.70	4.64	4.67	4.96	5.00	4.71	4.89
Petroleum Subtotal	37.92	41.21	40.83	40.55	40.28	44.30	44.10	42.35	42.44
Natural Gas	22.32	26.38	26.87	25.92	26.48	28.94	31.85	27.72	30.59
Metallurgical Coal	0.75	0.67	0.67	0.66	0.66	0.61	0.61	0.58	0.58
Steam Coal	20.59	23.59	19.62	23.41	19.75	24.81	14.90	24.43	15.37
Net Coal Coke Imports	0.06	0.11	0.11	0.08	0.08	0.15	0.15	0.09	0.09
Coal Subtotal	21.40	24.37	20.40	24.15	20.49	25.57	15.66	25.11	16.05
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.69	7.91	7.95	7.95
Renewable Energy[17]	6.53	7.10	8.61	7.45	8.30	7.87	9.59	8.24	9.78
Methanol (M85)[11]	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity Imports[16]	0.35	0.61	0.61	0.61	0.61	0.37	0.50	0.37	0.50
Total	**96.33**	**107.56**	**105.22**	**106.59**	**104.07**	**114.74**	**109.61**	**111.74**	**107.32**
Energy Use and Related Statistics									
Delivered Energy Use	72.05	80.17	79.80	79.29	79.02	86.01	85.01	83.61	82.98
Total Energy Use	96.33	107.56	105.22	106.59	104.07	114.74	109.61	111.74	107.32
Population (millions)	273.13	288.02	288.02	288.02	288.02	300.17	300.17	300.17	300.17
Gross Domestic Product (billion 1996 dollars)	8876	10960	10918	10960	10926	12667	12624	12667	12645
Carbon Dioxide Emissions (million metric tons carbon equivalent)	1510.8	1701.4	1599.3	1677.0	1585.6	1820.6	1603.6	1754.9	1564.1

[1]Includes wood used for residential heating. See Table C18 estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal hot water heating, and solar photovoltaic electricity generation.
[2]Includes ethanol (blends of 10 percent or less) and ethers blended into gasoline.
[3]Includes commercial sector electricity cogenerated by using wood and wood waste, landfill gas, municipal solid waste, and other biomass. See Table C18 for estimates of nonmarketed renewable energy consumption for solar thermal hot water heating and solar photovoltaic electricity generation.
[4]Fuel consumption includes consumption for cogeneration, which produces electricity and other useful thermal energy.
[5]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[6]Includes lease and plant fuel and consumption by cogenerators; excludes consumption by nonutility generators.
[7]Includes consumption of energy from hydroelectric, wood and wood waste, municipal solid waste, and other biomass; includes cogeneration, both for sale to the grid and for own use.
[8]Includes only kerosene type.
[9]Includes aviation gas and lubricants.
[10]E85 is 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable).
[11] M85 is 85 percent methanol and 15 percent motor gasoline.
[12]Includes unfinished oils, natural gasoline, motor gasoline blending compounds, aviation gasoline, lubricants, still gas, asphalt, road oil, petroleum coke, and miscellaneous petroleum products.
[13]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal hot water heaters.
[14]Includes consumption of energy by all electric power generators for grid-connected power except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[15]Includes conventional hydroelectric, geothermal, wood and wood waste, municipal solid waste, other biomass, petroleum coke, wind, photovoltaic and solar thermal sources. Excludes cogeneration. Excludes net electricity imports.
[16]In 1998 approximately 70 percent of the U.S. electricity imports were provided by renewable sources (hydroelectricity); EIA does not project future proportions for the fuel source of imported electricity.
[17]Includes hydroelectric, geothermal, wood and wood waste, municipal solid waste, other biomass, wind, photovoltaic and solar thermal sources. Includes ethanol components of E85; excludes ethanol blends (10 percent or less) in motor gasoline. Excludes net electricity imports and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal hot water heaters.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports. Consumption values of 0.00 are values that round to 0.00, because they are less than 0.005.
Sources: 1999 electric utility fuel consumption: Energy Information Administration (EIA), *Electric Power Annual 1998, Volume 1,* DOE/EIA-0348(98)/1 (Washington, DC, April 1999). 1999 nonutility consumption estimates: EIA, Form EIA-860B: "Annual Electric Generator Report - Nonutility." Other 1999 values: EIA, *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/ forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
10.21	10.09	9.40	9.28	10.88	10.77	9.83	9.72
0.12	0.12	0.11	0.11	0.12	0.12	0.11	0.11
5.22	5.21	5.14	5.14	5.96	5.96	5.84	5.84
3.23	3.29	3.19	3.21	3.41	3.48	3.34	3.42
20.43	20.40	18.45	18.45	21.56	21.51	18.69	18.71
1.61	1.60	1.59	1.59	1.69	1.69	1.67	1.67
1.40	1.31	1.28	1.27	1.41	1.33	1.26	1.27
5.12	5.16	4.82	5.02	5.33	5.43	4.97	5.11
47.33	47.19	43.98	44.07	50.36	50.30	45.71	45.85
32.60	35.92	30.55	33.73	35.88	39.32	33.16	36.49
0.55	0.55	0.52	0.52	0.50	0.50	0.46	0.46
25.29	13.58	24.64	14.43	25.58	12.55	24.49	13.57
0.19	0.19	0.09	0.09	0.22	0.22	0.10	0.10
26.03	14.32	25.25	15.05	26.30	13.27	25.05	14.13
6.98	7.68	7.84	7.91	6.51	7.15	7.18	7.69
8.17	9.98	8.67	10.21	8.38	10.45	9.08	10.64
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.23	0.36	0.23	0.36	0.24	0.37	0.24	0.37
121.34	**115.46**	**116.54**	**111.33**	**127.68**	**120.86**	**120.42**	**115.18**
91.70	90.82	87.65	87.09	97.25	96.47	91.70	91.34
121.34	115.46	116.54	111.33	127.68	120.86	120.42	115.18
312.58	312.58	312.58	312.58	325.24	325.24	325.24	325.24
14635	14633	14635	14636	16515	16468	16515	16506
1938.1	1681.5	1825.5	1609.8	2043.8	1756.7	1883.6	1653.0

Table C3. Energy Prices by Sector and Source
(1999 Dollars per Million Btu, Unless Otherwise Noted)

Sector and Source	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Residential	**13.18**	**13.33**	**14.16**	**13.23**	**13.93**	**13.41**	**15.70**	**13.12**	**14.99**
Primary Energy[1]	6.71	7.50	7.54	7.42	7.44	7.17	7.61	6.88	7.29
Petroleum Products[2]	7.55	9.17	9.15	9.10	9.08	9.37	9.45	9.28	9.26
Distillate Fuel	6.27	7.37	7.36	7.27	7.26	7.57	7.56	7.41	7.41
Liquefied Petroleum Gas	10.36	12.61	12.61	12.62	12.59	12.82	13.07	12.83	12.75
Natural Gas	6.52	7.13	7.18	7.05	7.07	6.70	7.22	6.38	6.88
Electricity	23.69	22.29	24.63	21.97	23.95	22.19	27.74	21.55	25.86
Commercial	**13.28**	**12.71**	**14.14**	**12.44**	**13.60**	**12.23**	**15.33**	**11.50**	**14.02**
Primary Energy[1]	5.22	5.58	5.61	5.47	5.49	5.65	6.09	5.32	5.74
Petroleum Products[2]	4.99	6.08	6.07	6.01	5.99	6.27	6.27	6.14	6.11
Distillate Fuel	4.37	5.17	5.15	5.07	5.06	5.35	5.32	5.19	5.18
Residual Fuel	2.63	3.64	3.61	3.64	3.60	3.70	3.69	3.70	3.69
Natural Gas[3]	5.34	5.57	5.61	5.46	5.48	5.63	6.15	5.26	5.77
Electricity	21.64	20.28	23.44	19.88	22.48	18.76	24.94	17.76	22.67
Industrial[4]	**5.29**	**5.75**	**6.07**	**5.62**	**5.88**	**5.62**	**6.50**	**5.27**	**5.98**
Primary Energy	3.91	4.46	4.47	4.37	4.38	4.45	4.73	4.18	4.43
Petroleum Products[2]	5.54	5.97	5.95	5.89	5.88	6.07	6.16	5.91	5.92
Distillate Fuel	4.65	5.33	5.32	5.24	5.23	5.53	5.50	5.35	5.35
Liquefied Petroleum Gas	8.50	7.75	7.75	7.72	7.71	7.77	8.08	7.74	7.73
Residual Fuel	2.78	3.37	3.34	3.37	3.34	3.43	3.42	3.43	3.42
Natural Gas[5]	2.79	3.66	3.71	3.55	3.58	3.46	4.02	3.07	3.60
Metallurgical Coal	1.66	1.58	1.59	1.53	1.54	1.54	1.55	1.45	1.46
Steam Coal	1.43	1.35	1.30	1.31	1.26	1.30	1.19	1.22	1.13
Electricity	13.12	12.81	15.06	12.52	14.39	12.04	16.84	11.29	15.13
Transportation	**8.30**	**9.33**	**9.36**	**9.19**	**9.18**	**9.63**	**9.73**	**9.24**	**9.18**
Primary Energy	8.29	9.32	9.34	9.18	9.16	9.61	9.70	9.23	9.16
Petroleum Products[2]	8.28	9.32	9.34	9.17	9.16	9.61	9.70	9.22	9.15
Distillate Fuel[6]	8.22	8.89	8.89	8.82	8.81	8.94	8.94	8.86	8.84
Jet Fuel[7]	4.70	5.22	5.23	5.17	5.16	5.49	5.48	5.39	5.37
Motor Gasoline[8]	9.45	10.75	10.78	10.58	10.55	11.20	11.36	10.68	10.57
Residual Fuel	2.46	3.11	3.09	3.11	3.09	3.18	3.17	3.18	3.18
Liquefied Petroleum Gas[9]	12.87	14.07	14.06	14.14	14.10	14.00	14.29	14.08	14.04
Natural Gas[10]	7.02	7.30	7.34	7.59	7.61	7.17	7.71	7.44	7.95
Ethanol (E85)[11]	14.42	19.20	19.23	19.13	19.13	19.13	19.24	18.93	18.94
Methanol (M85)[12]	10.38	13.13	13.19	12.99	13.01	13.80	13.83	12.94	13.17
Electricity	15.64	14.61	15.64	14.57	15.46	13.73	16.61	13.65	15.94
Average End-Use Energy	**8.52**	**9.16**	**9.56**	**9.00**	**9.33**	**9.16**	**10.17**	**8.75**	**9.52**
Primary Energy	6.31	7.16	7.18	7.04	7.03	7.30	7.51	6.93	7.06
Electricity	19.58	18.71	21.28	18.39	20.55	17.93	23.46	17.18	21.56
Electric Generators[13]									
Fossil Fuel Average	1.48	1.63	1.73	1.56	1.65	1.59	2.34	1.39	2.01
Petroleum Products	2.48	3.60	3.94	3.63	4.01	3.96	4.23	4.09	4.24
Distillate Fuel	4.07	4.65	4.80	4.57	4.73	4.85	4.90	4.69	4.82
Residual Fuel	2.39	3.43	3.79	3.45	3.86	3.70	4.10	3.87	4.14
Natural Gas	2.57	3.42	3.70	3.31	3.55	3.23	4.11	2.81	3.63
Steam Coal	1.21	1.13	1.05	1.10	1.01	1.06	0.98	0.98	0.93

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
13.51	**15.65**	**12.95**	**14.70**	**13.62**	**16.00**	**12.67**	**14.15**
7.05	7.38	6.57	6.95	7.01	7.48	6.31	6.68
9.35	9.33	9.14	9.22	9.47	9.48	9.23	9.22
7.54	7.52	7.37	7.45	7.76	7.74	7.48	7.52
12.84	12.79	12.47	12.50	12.71	12.72	12.49	12.26
6.59	7.00	6.07	6.50	6.56	7.11	5.79	6.21
22.20	27.51	21.11	25.11	22.16	27.83	20.41	23.66
12.39	**15.28**	**11.32**	**13.51**	**12.55**	**15.54**	**10.89**	**12.61**
5.62	5.96	5.11	5.48	5.69	6.15	4.94	5.30
6.23	6.17	6.07	6.12	6.37	6.32	6.17	6.14
5.30	5.27	5.14	5.21	5.51	5.47	5.25	5.28
3.78	3.76	3.78	3.77	3.85	3.84	3.85	3.84
5.61	6.00	5.04	5.47	5.67	6.21	4.84	5.26
18.78	24.87	17.38	21.81	18.83	25.32	16.56	20.14
5.65	**6.37**	**5.14**	**5.74**	**5.82**	**6.60**	**5.08**	**5.55**
4.47	4.64	4.08	4.29	4.61	4.86	4.08	4.25
6.01	6.01	5.80	5.80	6.12	6.13	5.85	5.80
5.49	5.47	5.32	5.40	5.71	5.69	5.43	5.47
7.79	7.82	7.32	7.36	7.68	7.76	7.30	7.17
3.51	3.50	3.51	3.50	3.58	3.58	3.59	3.58
3.56	3.96	2.97	3.42	3.73	4.32	2.88	3.30
1.49	1.49	1.37	1.37	1.44	1.44	1.28	1.29
1.25	1.13	1.15	1.05	1.21	1.07	1.07	0.98
11.97	16.83	10.92	14.56	12.07	17.30	10.36	13.39
9.28	**9.25**	**9.00**	**9.04**	**9.20**	**9.22**	**8.80**	**8.73**
9.26	9.22	8.98	9.02	9.18	9.19	8.79	8.71
9.26	9.22	8.98	9.01	9.18	9.18	8.78	8.70
8.88	8.85	8.64	8.75	8.83	8.82	8.52	8.57
5.54	5.53	5.48	5.48	5.72	5.72	5.50	5.50
10.70	10.64	10.43	10.44	10.60	10.61	10.24	10.08
3.26	3.25	3.25	3.26	3.33	3.32	3.33	3.33
13.94	13.92	13.65	13.67	13.64	13.71	13.49	13.30
7.28	7.68	7.43	7.85	7.30	7.84	7.22	7.63
19.27	19.31	19.09	19.15	19.34	19.42	17.13	16.91
14.17	14.14	14.01	14.01	14.35	14.35	14.00	14.02
13.43	16.24	13.28	15.44	13.18	15.99	12.75	14.35
9.08	**9.93**	**8.57**	**9.29**	**9.13**	**10.05**	**8.39**	**8.93**
7.16	7.24	6.75	6.89	7.20	7.33	6.63	6.69
17.93	23.43	16.80	20.90	17.96	23.86	16.12	19.51
1.71	2.53	1.39	2.04	1.85	2.91	1.40	2.10
4.04	4.31	4.18	4.37	4.20	4.46	4.41	4.59
4.83	4.92	4.67	4.86	5.05	5.15	4.79	5.02
3.79	4.19	3.98	4.27	3.92	4.34	4.22	4.50
3.39	4.04	2.73	3.45	3.62	4.44	2.70	3.37
1.02	0.91	0.92	0.84	0.98	0.84	0.85	0.78

Table C3. Energy Prices by Sector and Source (Continued)
(1999 Dollars per Million Btu, Unless Otherwise Noted)

Sector and Source	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Average Price to All Users[14]									
Petroleum Products[2]	7.46	8.48	8.53	8.36	8.37	8.75	8.85	8.43	8.38
Distillate Fuel	7.25	8.06	8.07	7.98	7.98	8.20	8.19	8.07	8.06
Jet Fuel	4.70	5.22	5.23	5.17	5.16	5.49	5.48	5.39	5.37
Liquefied Petroleum Gas	8.84	8.65	8.65	8.66	8.65	8.66	8.95	8.69	8.66
Motor Gasoline[8]	9.45	10.75	10.78	10.58	10.55	11.20	11.36	10.68	10.57
Residual Fuel	2.47	3.25	3.23	3.25	3.23	3.33	3.32	3.34	3.32
Natural Gas	4.04	4.73	4.81	4.63	4.68	4.43	4.96	4.09	4.56
Coal	1.23	1.15	1.07	1.11	1.04	1.08	1.01	1.00	0.95
Ethanol (E85)[11]	14.42	19.20	19.23	19.13	19.13	19.13	19.24	18.93	18.94
Methanol (M85)[12]	10.38	13.13	13.19	12.99	13.01	13.80	13.83	12.94	13.17
Electricity	19.58	18.71	21.28	18.39	20.55	17.93	23.46	17.18	21.56
Non-Renewable Energy Expenditures by Sector (billion 1999 dollars)									
Residential	135.11	154.23	162.14	150.34	156.99	158.26	179.04	149.48	165.63
Commercial	99.11	115.32	126.43	112.57	121.71	119.82	144.79	112.17	132.56
Industrial	112.11	126.41	133.52	122.62	128.30	131.84	152.47	121.33	137.69
Transportation	212.64	271.38	271.32	262.94	262.06	306.12	307.94	280.47	278.05
Total Non-Renewable Expenditures	558.97	667.34	693.42	648.46	669.06	716.05	784.24	663.45	713.92
Transportation Renewable Expenditures	0.14	0.42	0.42	0.58	0.58	0.62	0.63	0.90	0.89
Total Expenditures	**559.11**	**667.75**	**693.83**	**649.04**	**669.64**	**716.67**	**784.88**	**664.34**	**714.81**

[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 excludes county and local taxes.
[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: Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 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(99/03-2000/04) (Washington, DC, 1999-2000). 1999 prices for all other petroleum products are derived from the EIA, *State Energy Price and Expenditure Report 1997*, DOE/EIA-0376(97) (Washington, DC, July 2000). 1999 industrial gas delivered prices are based on EIA, *Manufacturing Energy Consumption Survey 1994*. 1999 residential and commercial natural gas delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). 1999 coal prices based on EIA, *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000) and EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. 1999 electricity prices for commercial, industrial, and transportation: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
8.50	8.48	8.22	8.25	8.49	8.49	8.10	8.03
8.16	8.14	7.91	8.01	8.20	8.19	7.86	7.92
5.54	5.53	5.48	5.48	5.72	5.72	5.50	5.50
8.63	8.64	8.25	8.31	8.48	8.55	8.21	8.09
10.70	10.64	10.43	10.44	10.60	10.60	10.24	10.08
3.41	3.40	3.41	3.41	3.49	3.48	3.49	3.49
4.41	4.80	3.86	4.28	4.50	5.09	3.70	4.12
1.04	0.94	0.94	0.87	0.99	0.88	0.87	0.80
19.27	19.31	19.09	19.15	19.34	19.42	17.13	16.91
14.17	14.14	14.01	14.01	14.35	14.35	14.00	14.02
17.93	23.43	16.80	20.90	17.96	23.86	16.12	19.51
167.03	187.38	152.80	168.31	177.68	201.30	156.76	170.48
128.83	154.26	117.09	136.17	135.53	163.98	117.37	133.28
139.94	158.25	123.79	138.18	152.08	174.01	127.41	139.31
319.67	317.40	285.76	286.38	340.13	339.43	292.12	289.36
755.47	817.30	679.45	729.04	805.42	878.72	693.65	732.44
0.74	0.74	1.10	1.10	0.85	0.85	1.24	1.21
756.21	**818.04**	**680.55**	**730.15**	**806.27**	**879.57**	**694.88**	**733.65**

Table C4. Residential Sector Key Indicators and End-Use Consumption
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Key Indicators									
Households (millions)									
Single-Family	75.70	81.28	81.26	81.28	81.27	85.38	85.36	85.39	85.37
Multifamily	21.79	23.06	23.04	23.06	23.05	24.16	24.14	24.17	24.15
Mobile Homes	6.59	6.93	6.93	6.93	6.93	7.19	7.20	7.20	7.19
Total	**104.08**	**111.26**	**111.23**	**111.27**	**111.24**	**116.74**	**116.69**	**116.75**	**116.71**
Average House Square Footage	**1673**	**1702**	**1702**	**1702**	**1702**	**1724**	**1724**	**1724**	**1724**
Energy Intensity									
(million Btu per household)									
Delivered Energy Consumption	102.4	107.7	106.7	105.7	104.9	104.7	101.3	100.9	97.9
Total Energy Consumption	183.5	194.5	187.3	192.5	184.6	190.3	174.5	185.4	170.9
(thousand Btu per square foot)									
Delivered Energy Consumption	61.2	63.3	62.7	62.1	61.6	60.7	58.8	58.5	56.8
Total Energy Consumption	109.7	114.3	110.0	113.1	108.5	110.4	101.2	107.6	99.2
Delivered Energy Consumption by Fuel									
Electricity									
Space Heating	0.38	0.45	0.43	0.43	0.41	0.47	0.43	0.43	0.40
Space Cooling	0.54	0.57	0.56	0.57	0.55	0.60	0.55	0.58	0.55
Water Heating	0.39	0.42	0.41	0.42	0.41	0.42	0.39	0.42	0.40
Refrigeration	0.42	0.38	0.38	0.38	0.38	0.34	0.34	0.34	0.34
Cooking	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12
Clothes Dryers	0.21	0.24	0.23	0.24	0.24	0.25	0.24	0.25	0.24
Freezers	0.12	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
Lighting	0.34	0.41	0.39	0.40	0.39	0.46	0.39	0.43	0.37
Clothes Washers[1]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dishwashers[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Color Televisions	0.12	0.17	0.16	0.17	0.16	0.19	0.18	0.19	0.18
Personal Computers	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.09
Furnace Fans	0.07	0.09	0.08	0.09	0.09	0.10	0.09	0.10	0.09
Other Uses[2]	1.10	1.48	1.43	1.48	1.45	1.73	1.62	1.74	1.65
Delivered Energy	**3.91**	**4.56**	**4.44**	**4.54**	**4.43**	**4.91**	**4.58**	**4.85**	**4.58**
Natural Gas									
Space Heating	3.24	3.76	3.76	3.60	3.60	3.77	3.71	3.50	3.44
Space Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Heating	1.27	1.37	1.37	1.39	1.39	1.34	1.32	1.36	1.34
Cooking	0.19	0.22	0.22	0.22	0.22	0.22	0.23	0.22	0.22
Clothes Dryers	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
Other Uses[3]	0.11	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11
Delivered Energy	**4.88**	**5.55**	**5.56**	**5.41**	**5.42**	**5.54**	**5.46**	**5.28**	**5.20**
Distillate									
Space Heating	0.73	0.74	0.74	0.72	0.72	0.69	0.69	0.63	0.63
Water Heating	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12
Other Uses[4]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delivered Energy	**0.86**	**0.87**	**0.87**	**0.84**	**0.84**	**0.80**	**0.81**	**0.75**	**0.75**
Liquefied Petroleum Gas									
Space Heating	0.31	0.32	0.32	0.30	0.30	0.29	0.30	0.27	0.27
Water Heating	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
Cooking	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Other Uses[3]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Delivered Energy	**0.46**	**0.46**	**0.46**	**0.44**	**0.45**	**0.43**	**0.43**	**0.40**	**0.40**
Marketed Renewables (wood)[5]	0.41	0.42	0.42	0.40	0.40	0.42	0.42	0.39	0.38
Other Fuels[6]	0.14	0.13	0.13	0.12	0.12	0.12	0.12	0.11	0.11

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
89.83	89.82	89.83	89.81	94.28	94.30	94.29	94.27
25.62	25.59	25.62	25.60	27.03	27.02	27.03	27.01
7.57	7.58	7.57	7.57	7.97	7.98	7.97	7.97
123.02	**123.00**	**123.03**	**122.99**	**129.28**	**129.30**	**129.30**	**129.25**
1744	**1744**	**1744**	**1744**	**1763**	**1763**	**1763**	**1763**
104.0	100.8	99.0	96.1	104.3	100.6	98.6	96.0
187.6	171.1	181.4	165.9	186.7	168.0	177.4	162.8
59.6	57.8	56.8	55.1	59.2	57.1	55.9	54.5
107.6	98.1	104.0	95.2	105.9	95.3	100.6	92.3
0.49	0.44	0.44	0.40	0.51	0.45	0.45	0.41
0.64	0.59	0.62	0.58	0.71	0.64	0.69	0.65
0.41	0.38	0.42	0.39	0.41	0.37	0.41	0.39
0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
0.13	0.12	0.13	0.12	0.13	0.13	0.13	0.13
0.26	0.25	0.27	0.25	0.28	0.26	0.28	0.27
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
0.49	0.42	0.44	0.38	0.52	0.44	0.44	0.39
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.21	0.20	0.22	0.21	0.24	0.22	0.24	0.23
0.10	0.09	0.09	0.09	0.11	0.11	0.10	0.10
0.11	0.10	0.11	0.10	0.12	0.11	0.12	0.11
1.97	1.86	2.00	1.90	2.21	2.07	2.25	2.16
5.27	**4.92**	**5.18**	**4.89**	**5.69**	**5.27**	**5.58**	**5.30**
3.98	3.94	3.60	3.55	4.24	4.18	3.77	3.72
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.35	1.34	1.38	1.37	1.37	1.36	1.42	1.41
0.24	0.24	0.24	0.24	0.25	0.26	0.25	0.25
0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.10
0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
5.78	**5.73**	**5.44**	**5.37**	**6.08**	**6.01**	**5.67**	**5.60**
0.67	0.67	0.59	0.59	0.66	0.66	0.56	0.56
0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.78	**0.78**	**0.70**	**0.70**	**0.76**	**0.77**	**0.66**	**0.67**
0.29	0.29	0.25	0.26	0.29	0.29	0.24	0.25
0.09	0.09	0.09	0.09	0.08	0.09	0.08	0.09
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.41	**0.42**	**0.38**	**0.39**	**0.41**	**0.42**	**0.36**	**0.38**
0.43	0.42	0.38	0.37	0.43	0.43	0.38	0.37
0.12	0.12	0.10	0.10	0.12	0.12	0.10	0.10

Table C4. Residential Sector Key Indicators and End-Use Consumption (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Delivered Energy Consumption by End-Use									
Space Heating	5.21	5.81	5.80	5.56	5.55	5.77	5.67	5.32	5.23
Space Cooling	0.54	0.58	0.56	0.57	0.55	0.60	0.55	0.59	0.55
Water Heating	1.90	2.02	2.00	2.04	2.03	1.96	1.92	1.98	1.94
Refrigeration	0.42	0.38	0.38	0.38	0.38	0.34	0.34	0.34	0.34
Cooking	0.32	0.37	0.37	0.37	0.37	0.37	0.38	0.37	0.38
Clothes Dryers	0.28	0.32	0.32	0.33	0.32	0.34	0.32	0.34	0.33
Freezers	0.12	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
Lighting	0.34	0.41	0.39	0.40	0.39	0.46	0.39	0.43	0.37
Clothes Washers	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dishwashers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Color Televisions	0.12	0.17	0.16	0.17	0.16	0.19	0.18	0.19	0.18
Personal Computers	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.09
Furnace Fans	0.07	0.09	0.08	0.09	0.09	0.10	0.09	0.10	0.09
Other Uses[7]	1.22	1.60	1.56	1.61	1.58	1.85	1.74	1.86	1.78
Delivered Energy	**10.66**	**11.99**	**11.87**	**11.76**	**11.66**	**12.22**	**11.83**	**11.77**	**11.43**
Electricity Related Losses	**8.44**	**9.66**	**8.96**	**9.67**	**8.87**	**10.00**	**8.54**	**9.87**	**8.52**
Total Energy Consumption by End-Use									
Space Heating	6.02	6.77	6.68	6.47	6.38	6.72	6.46	6.20	5.97
Space Cooling	1.70	1.79	1.68	1.77	1.66	1.82	1.58	1.78	1.57
Water Heating	2.75	2.90	2.83	2.94	2.85	2.82	2.65	2.84	2.68
Refrigeration	1.34	1.18	1.14	1.19	1.14	1.04	0.98	1.04	0.98
Cooking	0.54	0.60	0.59	0.61	0.59	0.62	0.60	0.62	0.60
Clothes Dryers	0.75	0.83	0.79	0.84	0.80	0.85	0.77	0.86	0.78
Freezers	0.37	0.30	0.29	0.31	0.29	0.27	0.25	0.27	0.25
Lighting	1.07	1.27	1.18	1.26	1.16	1.39	1.13	1.30	1.07
Clothes Washers	0.09	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.09
Dishwashers	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Color Televisions	0.38	0.52	0.49	0.52	0.49	0.57	0.51	0.58	0.52
Personal Computers	0.20	0.29	0.28	0.30	0.28	0.28	0.25	0.29	0.26
Furnace Fans	0.23	0.27	0.26	0.27	0.26	0.29	0.26	0.30	0.27
Other Uses[7]	3.59	4.73	4.46	4.77	4.48	5.37	4.77	5.41	4.85
Total	**19.10**	**21.65**	**20.83**	**21.43**	**20.54**	**22.22**	**20.36**	**21.65**	**19.95**
Non-Marketed Renewables									
Geothermal[8]	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Solar[9]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**

[1]Does not include electric water heating portion of load.
[2]Includes small electric devices, heating elements, and motors.
[3]Includes such appliances as swimming pool heaters, outdoor grills, and outdoor lighting (natural gas).
[4]Includes such appliances as swimming pool and hot tub heaters.
[5]Includes wood used for primary and secondary heating in wood stoves or fireplaces as reported in the *Residential Energy Consumption Survey 1997*.
[6]Includes kerosene and coal.
[7]Includes all other uses listed above.
[8]Includes primary energy displaced by geothermal heat pumps in space heating and cooling applications.
[9]Includes primary energy displaced by solar thermal water heaters and electricity generated using photovoltaics.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999: Energy Information Administration (EIA), *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
5.97	5.89	5.36	5.28	6.24	6.14	5.50	5.41
0.64	0.59	0.63	0.59	0.71	0.64	0.69	0.65
1.96	1.92	1.99	1.96	1.96	1.92	2.01	1.98
0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
0.40	0.40	0.40	0.40	0.42	0.42	0.42	0.42
0.36	0.34	0.36	0.35	0.38	0.36	0.39	0.38
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
0.49	0.42	0.44	0.38	0.52	0.44	0.44	0.39
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.21	0.20	0.22	0.21	0.24	0.22	0.24	0.23
0.10	0.09	0.09	0.09	0.11	0.11	0.10	0.10
0.11	0.10	0.11	0.10	0.12	0.11	0.12	0.11
2.09	1.98	2.12	2.02	2.32	2.19	2.37	2.28
12.79	**12.40**	**12.18**	**11.83**	**13.48**	**13.01**	**12.75**	**12.41**
10.28	**8.64**	**10.13**	**8.58**	**10.65**	**8.71**	**10.19**	**8.63**
6.92	6.66	6.22	5.97	7.20	6.88	6.31	6.07
1.89	1.62	1.85	1.61	2.03	1.70	1.94	1.71
2.76	2.60	2.81	2.64	2.72	2.53	2.76	2.61
0.95	0.89	0.96	0.89	0.93	0.86	0.92	0.85
0.64	0.62	0.64	0.62	0.66	0.64	0.66	0.63
0.87	0.78	0.88	0.80	0.89	0.79	0.90	0.82
0.25	0.24	0.25	0.24	0.25	0.23	0.25	0.23
1.44	1.16	1.29	1.04	1.49	1.16	1.24	1.02
0.09	0.08	0.09	0.08	0.08	0.07	0.08	0.07
0.08	0.07	0.08	0.07	0.08	0.07	0.08	0.07
0.63	0.56	0.64	0.57	0.69	0.60	0.69	0.61
0.29	0.26	0.26	0.23	0.33	0.29	0.29	0.26
0.31	0.28	0.32	0.28	0.33	0.29	0.33	0.30
5.94	5.24	6.04	5.36	6.45	5.61	6.49	5.79
23.08	**21.04**	**22.31**	**20.41**	**24.14**	**21.72**	**22.94**	**21.04**
0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.04	**0.03**	**0.04**	**0.04**	**0.04**	**0.03**	**0.04**	**0.04**

Table C5. Commercial Sector Key Indicators and Consumption
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Key Indicators									
Total Floor Space (billion square feet)									
Surviving	60.8	69.0	69.0	69.0	69.0	74.0	74.0	74.0	74.0
New Additions	2.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Total	**62.8**	**70.9**	**70.9**	**70.9**	**70.9**	**75.8**	**75.8**	**75.8**	**75.8**
Energy Consumption Intensity (thousand Btu per square foot)									
Delivered Energy Consumption	120.2	129.2	127.3	128.9	127.4	130.4	125.8	129.9	125.9
Electricity Related Losses	126.0	131.7	122.0	131.5	120.7	132.3	113.8	130.3	113.5
Total Energy Consumption	246.2	260.9	249.3	260.5	248.1	262.7	239.6	260.2	239.4
Delivered Energy Consumption by Fuel									
Purchased Electricity									
Space Heating[1]	0.14	0.16	0.15	0.16	0.15	0.16	0.15	0.16	0.15
Space Cooling[1]	0.45	0.44	0.42	0.44	0.42	0.45	0.42	0.45	0.43
Water Heating[1]	0.14	0.15	0.15	0.15	0.15	0.16	0.15	0.16	0.15
Ventilation	0.17	0.19	0.18	0.19	0.18	0.20	0.18	0.20	0.19
Cooking	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Lighting	1.21	1.31	1.24	1.31	1.25	1.40	1.23	1.39	1.26
Refrigeration	0.18	0.20	0.20	0.20	0.20	0.21	0.20	0.21	0.21
Office Equipment (PC)	0.10	0.18	0.18	0.16	0.16	0.24	0.23	0.21	0.21
Office Equipment (non-PC)	0.30	0.41	0.41	0.41	0.41	0.51	0.50	0.51	0.50
Other Uses[2]	0.94	1.34	1.33	1.32	1.32	1.56	1.54	1.52	1.50
Delivered Energy	**3.66**	**4.40**	**4.28**	**4.38**	**4.27**	**4.92**	**4.63**	**4.85**	**4.62**
Natural Gas[3]									
Space Heating[1]	1.42	1.64	1.64	1.64	1.64	1.71	1.65	1.73	1.68
Space Cooling[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Water Heating[1]	0.64	0.70	0.70	0.70	0.70	0.76	0.73	0.76	0.74
Cooking	0.21	0.23	0.23	0.23	0.23	0.25	0.24	0.25	0.24
Other Uses[4]	0.86	1.40	1.40	1.41	1.41	1.45	1.47	1.46	1.47
Delivered Energy	**3.14**	**3.99**	**3.99**	**4.00**	**4.00**	**4.19**	**4.12**	**4.22**	**4.15**
Distillate									
Space Heating[1]	0.23	0.26	0.26	0.26	0.26	0.26	0.27	0.26	0.26
Water Heating[1]	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Other Uses[5]	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Delivered Energy	**0.36**	**0.37**	**0.37**	**0.37**	**0.37**	**0.38**	**0.39**	**0.37**	**0.37**
Other Fuels[6]	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.31**	**0.31**	**0.31**	**0.31**
Marketed Renewable Fuels									
Biomass	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Delivered Energy	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Delivered Energy Consumption by End-Use									
Space Heating[1]	1.79	2.06	2.05	2.06	2.05	2.14	2.07	2.15	2.09
Space Cooling[1]	0.46	0.46	0.44	0.46	0.45	0.47	0.44	0.48	0.45
Water Heating[1]	0.87	0.94	0.94	0.95	0.94	1.00	0.96	1.01	0.97
Ventilation	0.17	0.19	0.18	0.19	0.18	0.20	0.18	0.20	0.19
Cooking	0.24	0.26	0.26	0.26	0.26	0.28	0.27	0.28	0.27
Lighting	1.21	1.31	1.24	1.31	1.25	1.40	1.23	1.39	1.26
Refrigeration	0.18	0.20	0.20	0.20	0.20	0.21	0.20	0.21	0.21
Office Equipment (PC)	0.10	0.18	0.18	0.16	0.16	0.24	0.23	0.21	0.21
Office Equipment (non-PC)	0.30	0.41	0.41	0.41	0.41	0.51	0.50	0.51	0.50
Other Uses[7]	2.23	3.15	3.14	3.14	3.13	3.43	3.43	3.40	3.39
Delivered Energy	**7.55**	**9.15**	**9.02**	**9.14**	**9.03**	**9.88**	**9.53**	**9.84**	**9.54**

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
78.1	78.1	78.1	78.1	80.7	80.7	80.7	80.7
1.5	1.5	1.5	1.5	1.3	1.3	1.3	1.3
79.6	**79.6**	**79.6**	**79.6**	**81.9**	**81.9**	**81.9**	**81.9**
131.7	127.8	131.0	127.6	132.8	129.8	132.5	130.1
131.0	109.9	128.7	109.3	128.9	104.4	123.0	103.4
262.7	237.7	259.7	236.9	261.7	234.1	255.6	233.5
0.16	0.15	0.16	0.15	0.16	0.14	0.16	0.15
0.46	0.42	0.46	0.44	0.46	0.41	0.47	0.44
0.16	0.14	0.16	0.15	0.16	0.14	0.16	0.15
0.21	0.18	0.21	0.19	0.21	0.18	0.21	0.19
0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03
1.45	1.24	1.45	1.28	1.45	1.20	1.46	1.28
0.22	0.21	0.22	0.21	0.22	0.21	0.22	0.21
0.28	0.27	0.25	0.24	0.29	0.28	0.26	0.25
0.60	0.58	0.60	0.59	0.69	0.66	0.69	0.67
1.79	1.75	1.70	1.68	1.98	1.92	1.86	1.82
5.35	**4.98**	**5.24**	**4.96**	**5.64**	**5.17**	**5.52**	**5.21**
1.77	1.69	1.80	1.74	1.80	1.67	1.85	1.77
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.81	0.76	0.81	0.77	0.84	0.76	0.85	0.79
0.26	0.25	0.27	0.26	0.27	0.26	0.29	0.28
1.49	1.67	1.51	1.63	1.54	1.94	1.57	1.81
4.36	**4.40**	**4.42**	**4.43**	**4.47**	**4.67**	**4.58**	**4.68**
0.26	0.28	0.25	0.25	0.25	0.27	0.24	0.24
0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.08
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.38	**0.39**	**0.37**	**0.37**	**0.37**	**0.39**	**0.35**	**0.36**
0.32	**0.32**	**0.32**	**0.32**	**0.32**	**0.32**	**0.32**	**0.32**
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
0.08	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
2.19	2.12	2.22	2.15	2.21	2.09	2.25	2.17
0.48	0.44	0.49	0.46	0.48	0.43	0.49	0.47
1.05	0.99	1.06	1.01	1.08	0.99	1.09	1.03
0.21	0.18	0.21	0.19	0.21	0.18	0.21	0.19
0.29	0.28	0.30	0.29	0.30	0.29	0.32	0.30
1.45	1.24	1.45	1.28	1.45	1.20	1.46	1.28
0.22	0.21	0.22	0.21	0.22	0.21	0.22	0.21
0.28	0.27	0.25	0.24	0.29	0.28	0.26	0.25
0.60	0.58	0.60	0.59	0.69	0.66	0.69	0.67
3.71	3.85	3.64	3.73	3.96	4.30	3.86	4.07
10.48	**10.18**	**10.43**	**10.16**	**10.88**	**10.63**	**10.86**	**10.66**

Table C5. Commercial Sector Key Indicators and Consumption (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Electricity Related Losses	**7.91**	**9.33**	**8.64**	**9.32**	**8.55**	**10.02**	**8.62**	**9.87**	**8.60**
Total Energy Consumption by End-Use									
Space Heating[1]	2.09	2.39	2.35	2.40	2.36	2.47	2.35	2.48	2.38
Space Cooling[1]	1.43	1.38	1.29	1.39	1.30	1.39	1.21	1.40	1.25
Water Heating[1]	1.18	1.27	1.23	1.27	1.24	1.33	1.23	1.33	1.25
Ventilation	0.55	0.59	0.55	0.60	0.55	0.61	0.52	0.61	0.53
Cooking	0.31	0.32	0.32	0.33	0.32	0.34	0.32	0.35	0.33
Lighting	3.81	4.09	3.74	4.11	3.75	4.25	3.53	4.23	3.60
Refrigeration	0.58	0.63	0.59	0.63	0.59	0.65	0.58	0.65	0.59
Office Equipment (PC)	0.33	0.55	0.53	0.50	0.48	0.72	0.67	0.64	0.59
Office Equipment (non-PC)	0.93	1.28	1.23	1.29	1.23	1.54	1.43	1.55	1.44
Other Uses[7]	4.25	5.98	5.83	5.95	5.77	6.61	6.30	6.48	6.18
Total	**15.46**	**18.48**	**17.66**	**18.45**	**17.58**	**19.90**	**18.15**	**19.71**	**18.14**
Non-Marketed Renewable Fuels									
Solar[8]	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Total	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**

[1]Includes fuel consumption for district services.
[2]Includes miscellaneous uses, such as service station equipment, automated teller machines, telecommunications equipment, and medical equipment.
[3]Excludes estimated consumption from independent power producers.
[4]Includes miscellaneous uses, such as pumps, emergency electric generators, cogeneration in commercial buildings, and manufacturing performed in commercial buildings.
[5]Includes miscellaneous uses, such as cooking, emergency electric generators, and cogeneration in commercial buildings.
[6]Includes residual fuel oil, liquefied petroleum gas, coal, motor gasoline, and kerosene.
[7]Includes miscellaneous uses, such as service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, lighting, emergency electric generators, cogeneration in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, liquefied petroleum gas, coal, motor gasoline, and kerosene.
[8]Includes primary energy displaced by solar thermal space heating and water heating, and electricity generation by solar photovoltaic systems.
Btu = British thermal unit.
PC = Personal computer.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999: Energy Information Administration (EIA), *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
10.43	**8.75**	**10.24**	**8.70**	**10.56**	**8.55**	**10.08**	**8.47**
2.51	2.38	2.53	2.42	2.51	2.33	2.54	2.41
1.38	1.18	1.40	1.23	1.34	1.11	1.35	1.18
1.36	1.25	1.37	1.27	1.37	1.22	1.38	1.26
0.61	0.51	0.61	0.53	0.60	0.48	0.59	0.51
0.35	0.33	0.36	0.34	0.35	0.33	0.37	0.35
4.28	3.43	4.27	3.53	4.16	3.19	4.13	3.37
0.65	0.58	0.65	0.58	0.64	0.55	0.64	0.56
0.82	0.75	0.73	0.67	0.84	0.75	0.73	0.67
1.77	1.61	1.78	1.62	1.98	1.76	1.95	1.77
7.19	6.92	6.97	6.68	7.67	7.48	7.25	7.04
20.91	**18.92**	**20.67**	**18.86**	**21.44**	**19.18**	**20.94**	**19.13**
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.03	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**

Table C6. Industrial Sector Key Indicators and Consumption
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Key Indicators									
Value of Gross Output (billion 1992 dollars)									
Manufacturing	3749	4372	4367	4371	4367	5061	5058	5057	5060
Nonmanufacturing	972	1067	1061	1066	1062	1162	1154	1160	1157
Total	**4722**	**5438**	**5428**	**5437**	**5429**	**6223**	**6212**	**6217**	**6217**
Energy Prices (1999 dollars per million Btu)									
Electricity	13.12	12.81	15.06	12.52	14.39	12.04	16.84	11.29	15.13
Natural Gas	2.79	3.66	3.71	3.55	3.58	3.46	4.02	3.07	3.60
Steam Coal	1.43	1.35	1.30	1.31	1.26	1.30	1.19	1.22	1.13
Residual Oil	2.78	3.37	3.34	3.37	3.34	3.43	3.42	3.43	3.42
Distillate Oil	4.65	5.33	5.32	5.24	5.23	5.53	5.50	5.35	5.35
Liquefied Petroleum Gas	8.50	7.75	7.75	7.72	7.71	7.77	8.08	7.74	7.73
Motor Gasoline	9.42	10.73	10.76	10.55	10.52	11.19	11.34	10.66	10.54
Metallurgical Coal	1.66	1.58	1.59	1.53	1.54	1.54	1.55	1.45	1.46
Energy Consumption									
Consumption[1]									
Purchased Electricity	3.61	3.88	3.78	3.83	3.73	4.16	3.88	4.03	3.79
Natural Gas[2]	9.80	10.42	10.44	10.35	10.37	11.27	11.34	11.22	11.24
Steam Coal	1.73	1.80	1.81	1.79	1.80	1.82	1.79	1.79	1.75
Metallurgical Coal and Coke[3]	0.81	0.78	0.78	0.74	0.74	0.76	0.76	0.67	0.67
Residual Fuel	0.22	0.16	0.16	0.16	0.16	0.25	0.26	0.24	0.25
Distillate	1.13	1.21	1.20	1.20	1.20	1.30	1.29	1.28	1.28
Liquefied Petroleum Gas	2.32	2.44	2.44	2.42	2.42	2.51	2.56	2.47	2.52
Petrochemical Feedstocks	1.29	1.36	1.35	1.35	1.35	1.53	1.52	1.52	1.52
Other Petroleum[4]	4.50	4.64	4.66	4.60	4.63	4.92	4.97	4.67	4.85
Renewables[5]	2.15	2.40	2.40	2.48	2.47	2.63	2.62	2.81	2.81
Delivered Energy	**27.56**	**29.10**	**29.03**	**28.92**	**28.89**	**31.14**	**30.98**	**30.69**	**30.67**
Electricity Related Losses	7.80	8.21	7.64	8.16	7.47	8.47	7.22	8.20	7.05
Total	**35.36**	**37.31**	**36.67**	**37.08**	**36.36**	**39.61**	**38.21**	**38.90**	**37.72**
Consumption per Unit of Output[1] (thousand Btu per 1992 dollars)									
Purchased Electricity	0.76	0.71	0.70	0.70	0.69	0.67	0.62	0.65	0.61
Natural Gas[2]	2.08	1.92	1.92	1.90	1.91	1.81	1.83	1.80	1.81
Steam Coal	0.37	0.33	0.33	0.33	0.33	0.29	0.29	0.29	0.28
Metallurgical Coal and Coke[3]	0.17	0.14	0.14	0.14	0.14	0.12	0.12	0.11	0.11
Residual Fuel	0.05	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Distillate	0.24	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21
Liquefied Petroleum Gas	0.49	0.45	0.45	0.44	0.45	0.40	0.41	0.40	0.41
Petrochemical Feedstocks	0.27	0.25	0.25	0.25	0.25	0.25	0.25	0.24	0.24
Other Petroleum[4]	0.95	0.85	0.86	0.85	0.85	0.79	0.80	0.75	0.78
Renewables[5]	0.46	0.44	0.44	0.46	0.46	0.42	0.42	0.45	0.45
Delivered Energy	**5.84**	**5.35**	**5.35**	**5.32**	**5.32**	**5.00**	**4.99**	**4.94**	**4.93**
Electricity Related Losses	1.65	1.51	1.41	1.50	1.38	1.36	1.16	1.32	1.13
Total	**7.49**	**6.86**	**6.76**	**6.82**	**6.70**	**6.37**	**6.15**	**6.26**	**6.07**

[1]Fuel consumption includes consumption for cogeneration.
[2]Includes lease and plant fuel.
[3]Includes net coke coal imports.
[4]Includes petroleum coke, asphalt, road oil, lubricants, motor gasoline, still gas, and miscellaneous petroleum products.
[5]Includes consumption of energy from hydroelectric, wood and wood waste, municipal solid waste, and other biomass.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 prices for gasoline and distillate are based on prices in various issues of Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380 (99/03-2000/04) (Washington, DC, 1999-2000). 1999 coal prices are based on EIA, *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000) and EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. 1999 electricity prices: EIA, AEO2001 National Energy Modeling System runsSCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. Other 1999 prices derived from EIA, *State Energy Data Report 1997*, DOE/EIA-0214(97) (Washington, DC, September 1999). Other 1999 values: EIA, *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf.
Projections: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
5816	5821	5807	5808	6712	6736	6704	6705
1266	1257	1262	1259	1371	1362	1365	1363
7082	**7078**	**7070**	**7068**	**8083**	**8098**	**8069**	**8068**
11.97	16.83	10.92	14.56	12.07	17.30	10.36	13.39
3.56	3.96	2.97	3.42	3.73	4.32	2.88	3.30
1.25	1.13	1.15	1.05	1.21	1.07	1.07	0.98
3.51	3.50	3.51	3.50	3.58	3.58	3.59	3.58
5.49	5.47	5.32	5.40	5.71	5.69	5.43	5.47
7.79	7.82	7.32	7.36	7.68	7.76	7.30	7.17
10.68	10.62	10.41	10.42	10.56	10.58	10.22	10.05
1.49	1.49	1.37	1.37	1.44	1.44	1.28	1.29
4.43	3.98	4.24	3.85	4.76	4.14	4.50	4.02
12.03	12.32	11.88	12.09	12.71	13.21	12.39	12.78
1.84	1.82	1.79	1.77	1.86	1.87	1.78	1.76
0.74	0.74	0.62	0.61	0.72	0.72	0.56	0.56
0.26	0.27	0.21	0.24	0.27	0.29	0.21	0.25
1.39	1.39	1.36	1.35	1.49	1.49	1.43	1.43
2.67	2.72	2.60	2.61	2.85	2.90	2.74	2.80
1.61	1.60	1.59	1.59	1.69	1.69	1.67	1.67
5.08	5.12	4.77	4.97	5.28	5.38	4.92	5.06
2.85	2.85	3.17	3.17	3.07	3.07	3.55	3.55
32.90	**32.80**	**32.22**	**32.26**	**34.72**	**34.76**	**33.76**	**33.88**
8.64	6.99	8.30	6.77	8.91	6.85	8.22	6.54
41.54	**39.79**	**40.52**	**39.03**	**43.63**	**41.61**	**41.98**	**40.42**
0.63	0.56	0.60	0.55	0.59	0.51	0.56	0.50
1.70	1.74	1.68	1.71	1.57	1.63	1.54	1.58
0.26	0.26	0.25	0.25	0.23	0.23	0.22	0.22
0.10	0.10	0.09	0.09	0.09	0.09	0.07	0.07
0.04	0.04	0.03	0.03	0.03	0.04	0.03	0.03
0.20	0.20	0.19	0.19	0.18	0.18	0.18	0.18
0.38	0.38	0.37	0.37	0.35	0.36	0.34	0.35
0.23	0.23	0.22	0.22	0.21	0.21	0.21	0.21
0.72	0.72	0.68	0.70	0.65	0.66	0.61	0.63
0.40	0.40	0.45	0.45	0.38	0.38	0.44	0.44
4.65	**4.63**	**4.56**	**4.57**	**4.30**	**4.29**	**4.18**	**4.20**
1.22	0.99	1.17	0.96	1.10	0.85	1.02	0.81
5.87	**5.62**	**5.73**	**5.52**	**5.40**	**5.14**	**5.20**	**5.01**

Table C7. Transportation Sector Key Indicators and Delivered Energy Consumption

Key Indicators and Consumption	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Key Indicators									
Level of Travel (billions)									
Light-Duty Vehicles <8,500 pounds (VMT)	2394	2765	2761	2769	2768	3059	3053	3072	3073
Commercial Light Trucks (VMT)[1]	73	83	83	83	83	93	93	93	93
Freight Trucks >10,000 pounds (VMT)	204	247	246	247	246	279	278	278	278
Air (seat miles available)	1099	1305	1301	1306	1304	1586	1582	1586	1587
Rail (ton miles traveled)	1353	1569	1475	1568	1480	1708	1450	1701	1462
Domestic Shipping (ton miles traveled)	661	736	727	733	727	778	756	771	765
Energy Efficiency Indicators									
New Light-Duty Vehicle (miles per gallon)[2]	24.2	26.1	26.1	28.7	28.7	27.2	27.3	31.9	31.8
New Car (miles per gallon)[2]	27.9	30.9	31.0	33.1	33.1	32.5	32.5	36.3	36.2
New Light Truck (miles per gallon)[2]	20.8	22.3	22.3	25.1	25.1	23.3	23.4	28.3	28.3
Light-Duty Fleet (miles per gallon)[3]	20.5	20.7	20.7	21.2	21.2	21.0	21.0	22.3	22.3
New Commercial Light Truck (MPG)[1]	20.1	21.2	21.2	24.0	24.0	22.1	22.1	26.8	26.8
Stock Commercial Light Truck (MPG)[1]	14.8	15.6	15.6	16.0	16.0	16.1	16.1	17.2	17.2
Aircraft Efficiency (seat miles per gallon)	51.7	54.0	54.0	54.0	54.0	56.1	56.1	56.1	56.1
Freight Truck Efficiency (miles per gallon)	6.0	6.2	6.2	6.3	6.3	6.4	6.4	6.7	6.7
Rail Efficiency (ton miles per thousand Btu)	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.3	3.3
Domestic Shipping Efficiency (ton miles per thousand Btu)	2.3	2.5	2.5	2.5	2.5	2.7	2.7	2.7	2.7
Energy Use by Mode (quadrillion Btu)									
Light-Duty Vehicles	14.88	16.91	16.89	16.52	16.52	18.43	18.39	17.29	17.30
Commercial Light Trucks[1]	0.62	0.67	0.67	0.65	0.65	0.72	0.72	0.68	0.68
Freight Trucks[4]	4.55	5.28	5.27	5.24	5.24	5.76	5.75	5.57	5.57
Air[5]	3.50	3.93	3.92	3.93	3.93	4.55	4.54	4.54	4.55
Rail[6]	0.57	0.62	0.59	0.61	0.58	0.65	0.57	0.62	0.55
Marine[7]	1.29	1.44	1.44	1.43	1.43	1.46	1.46	1.45	1.45
Pipeline Fuel	0.66	0.82	0.84	0.81	0.83	0.90	0.96	0.87	0.97
Lubricants	0.22	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.26
Total	**26.28**	**29.94**	**29.88**	**29.47**	**29.44**	**32.77**	**32.67**	**31.30**	**31.34**
Energy Use by Mode (million barrels per day oil equivalent)									
Light-Duty Vehicles	7.76	8.87	8.86	8.68	8.68	9.66	9.63	9.08	9.08
Commercial Light Trucks[1]	0.32	0.35	0.35	0.34	0.34	0.38	0.38	0.35	0.35
Freight Trucks[4]	2.03	2.37	2.36	2.35	2.35	2.59	2.58	2.50	2.50
Railroad	0.23	0.25	0.24	0.24	0.23	0.26	0.22	0.25	0.21
Domestic Shipping	0.13	0.14	0.13	0.13	0.13	0.14	0.13	0.13	0.13
International Shipping	0.30	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Air[5]	1.46	1.66	1.66	1.66	1.66	1.94	1.94	1.94	1.94
Military Use	0.28	0.29	0.29	0.29	0.29	0.32	0.32	0.32	0.32
Bus Transportation	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Rail Transportation[6]	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Recreational Boats	0.16	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.18
Lubricants	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Pipeline Fuel	0.33	0.42	0.43	0.41	0.42	0.46	0.49	0.44	0.49
Total	**13.24**	**15.11**	**15.08**	**14.88**	**14.87**	**16.53**	**16.48**	**15.79**	**15.82**

[1]Commercial trucks 8,500 to 10,000 pounds.
[2]Environmental Protection Agency rated miles per gallon.
[3]Combined car and light truck "on-the-road" estimate.
[4]Includes energy use by buses and military distillate consumption.
[5]Includes jet fuel and aviation gasoline.
[6]Includes passenger rail.
[7]Includes military residual fuel use and recreation boats.
Btu = British thermal unit.
VMT=Vehicle miles traveled.
MPG = Miles per gallon.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999: U.S. Department of Transportation, Research and Special Programs Administration, *Air Carrier Statistics Monthly, December 1999/1998* (Washington, DC, 1999); Energy Information Administration (EIA), *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf; EIA, *Fuel Oil and Kerosene Sales 1998*, DOE/EIA-0535(98) (Washington, DC, August 1999); and United States Department of Defense, Defense Fuel Supply Center. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
3331	3331	3348	3348	3575	3573	3597	3599
103	103	103	103	112	112	113	113
313	313	312	312	352	352	352	351
1933	1933	1934	1934	2316	2316	2318	2318
1840	1521	1821	1543	1967	1611	1932	1633
834	808	824	816	890	861	873	869
27.6	27.7	33.7	33.7	28.1	28.1	34.9	34.8
32.5	32.5	37.9	37.9	32.5	32.5	39.1	39.0
24.0	24.0	30.2	30.2	24.7	24.7	31.4	31.4
21.3	21.3	23.7	23.7	21.5	21.6	25.1	25.1
22.8	22.8	28.3	28.3	23.4	23.5	29.4	29.4
16.6	16.6	18.5	18.5	17.0	17.0	19.6	19.6
58.2	58.2	59.1	59.1	60.3	60.3	61.8	61.8
6.7	6.7	7.1	7.1	6.9	6.9	7.5	7.5
3.3	3.3	3.5	3.5	3.4	3.4	3.8	3.8
2.8	2.8	3.0	3.0	3.0	3.0	3.2	3.2
19.76	19.73	17.73	17.73	20.92	20.88	18.05	18.07
0.77	0.77	0.70	0.70	0.83	0.82	0.72	0.72
6.23	6.22	5.83	5.83	6.73	6.73	6.18	6.18
5.28	5.27	5.20	5.20	6.04	6.04	5.91	5.91
0.67	0.57	0.63	0.55	0.69	0.58	0.63	0.55
1.49	1.48	1.47	1.47	1.52	1.51	1.49	1.48
1.01	1.06	0.95	1.05	1.10	1.15	1.02	1.13
0.29	0.29	0.29	0.29	0.31	0.31	0.31	0.31
35.53	**35.44**	**32.82**	**32.84**	**38.16**	**38.07**	**34.34**	**34.39**
10.35	10.33	9.32	9.32	10.95	10.93	9.49	9.50
0.41	0.40	0.36	0.36	0.43	0.43	0.38	0.38
2.81	2.80	2.62	2.62	3.04	3.04	2.79	2.79
0.27	0.22	0.24	0.21	0.27	0.22	0.24	0.20
0.14	0.13	0.13	0.13	0.14	0.13	0.12	0.12
0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
2.28	2.27	2.24	2.24	2.63	2.63	2.57	2.57
0.34	0.34	0.34	0.34	0.36	0.36	0.36	0.36
0.09	0.09	0.08	0.08	0.09	0.09	0.08	0.08
0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.20
0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15
0.51	0.54	0.48	0.53	0.55	0.58	0.52	0.57
17.90	**17.86**	**16.55**	**16.56**	**19.22**	**19.18**	**17.30**	**17.33**

Table C8. Electricity Supply, Disposition, Prices, and Emissions
(Billion Kilowatthours, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Generation by Fuel Type									
Electric Generators[1]									
Coal	1830	2105	1739	2091	1753	2238	1276	2240	1324
Petroleum	85	42	14	36	13	25	11	20	11
Natural Gas[2]	370	582	788	560	780	826	1395	719	1292
Nuclear Power	730	740	740	740	740	720	741	744	744
Pumped Storage	-1	-1	-1	-1	-1	-1	-1	-1	-1
Renewable Sources[3]	355	372	455	383	431	396	492	402	515
Total	**3369**	**3839**	**3735**	**3809**	**3716**	**4204**	**3914**	**4125**	**3885**
Nonutility Generation for Own Use	16	17	21	17	21	17	19	17	19
Distributed Generation	0	0	0	0	0	1	0	1	0
Cogenerators[4]									
Coal	47	53	52	53	52	51	46	51	46
Petroleum	9	10	10	10	10	10	10	10	10
Natural Gas	206	236	249	237	251	259	320	260	316
Other Gaseous Fuels[5]	4	6	6	6	6	7	7	7	7
Renewable Sources[3]	31	34	34	36	35	39	39	43	43
Other[6]	5	5	5	5	5	5	5	5	5
Total	**303**	**344**	**357**	**347**	**360**	**372**	**426**	**376**	**427**
Other End-Use Generators[7]	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Sales to Utilities	151	172	171	172	172	179	182	180	182
Generation for Own Use	156	177	190	179	193	197	249	202	250
Net Imports[8]	**33**	**57**	**57**	**57**	**57**	**35**	**47**	**35**	**47**
Electricity Sales by Sector									
Residential	1145	1337	1300	1330	1299	1438	1344	1421	1343
Commercial	1073	1291	1254	1283	1252	1442	1357	1421	1355
Industrial	1058	1137	1108	1122	1094	1219	1137	1180	1110
Transportation	17	26	26	22	22	34	34	27	27
Total	**3294**	**3790**	**3688**	**3757**	**3667**	**4133**	**3872**	**4049**	**3835**
End-Use Prices (1999 cents per kwh)[9]									
Residential	8.1	7.6	8.4	7.5	8.2	7.6	9.5	7.4	8.8
Commercial	7.4	6.9	8.0	6.8	7.7	6.4	8.5	6.1	7.7
Industrial	4.5	4.4	5.1	4.3	4.9	4.1	5.7	3.9	5.2
Transportation	5.3	5.0	5.3	5.0	5.3	4.7	5.7	4.7	5.4
All Sectors Average	**6.7**	**6.4**	**7.3**	**6.3**	**7.0**	**6.1**	**8.0**	**5.9**	**7.4**
Prices by Service Category[9] (1999 cents per kilowatthour)									
Generation	4.1	3.8	4.6	3.7	4.4	3.4	5.2	3.2	4.5
Transmission	0.6	0.6	0.7	0.6	0.7	0.7	0.8	0.7	0.8
Distribution	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.0	2.1
Emissions (million short tons)									
Sulfur Dioxide	13.49	10.39	6.34	10.39	6.34	9.70	2.99	9.70	2.99
Nitrogen Oxide	5.43	4.30	2.70	4.26	2.67	4.34	1.64	4.18	1.76

[1]Includes grid-connected generation at all utilities and nonutilities except for cogenerators. Includes small power producers and exempt wholesale generators.
[2]Includes electricity generation by fuel cells.
[3]Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar, and wind power.
[4]Cogenerators produce electricity and other useful thermal energy. Includes sales to utilities and generation for own use.
[5]Other gaseous fuels include refinery and still gas.
[6]Other includes hydrogen, sulfur, batteries, chemicals, fish oil, and spent sulfite liquor.
[7]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.
[8]In 1999 approximately 70 percent of the U.S. electricity imports were provided by renewable sources (hydroelectricity); EIA does not project future proportions for the fuel source of imported electricity.
[9]Prices represent average revenue per kilowatthour.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
2279	1146	2260	1230	2302	1041	2246	1146
24	12	18	10	23	11	16	10
1168	1759	985	1584	1488	2072	1331	1911
653	719	735	741	610	669	672	720
-1	-1	-1	-1	-1	-1	-1	-1
400	500	408	519	399	519	409	524
4524	**4135**	**4405**	**4084**	**4821**	**4311**	**4674**	**4309**
17	18	16	19	16	18	16	19
3	1	2	0	5	1	4	1
52	44	51	45	52	44	51	42
10	10	10	10	10	10	10	10
287	420	286	402	317	548	311	484
8	8	7	7	8	9	7	8
44	44	51	51	48	48	59	59
5	5	5	5	6	6	5	5
406	**532**	**411**	**520**	**440**	**664**	**444**	**608**
5	**5**	**5**	**5**	**5**	**5**	**5**	**5**
193	211	194	210	208	253	209	238
218	326	222	315	237	415	239	374
22	**34**	**22**	**34**	**23**	**35**	**23**	**35**
1545	1442	1518	1432	1668	1543	1636	1554
1567	1459	1535	1452	1653	1515	1618	1526
1298	1166	1243	1129	1394	1213	1320	1178
43	43	32	32	49	48	36	36
4453	**4109**	**4328**	**4046**	**4763**	**4320**	**4610**	**4294**
7.6	9.4	7.2	8.6	7.6	9.5	7.0	8.1
6.4	8.5	5.9	7.4	6.4	8.6	5.6	6.9
4.1	5.7	3.7	5.0	4.1	5.9	3.5	4.6
4.6	5.5	4.5	5.3	4.5	5.5	4.3	4.9
6.1	**8.0**	**5.7**	**7.1**	**6.1**	**8.1**	**5.5**	**6.7**
3.4	5.2	3.0	4.4	3.5	5.5	2.9	4.0
0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
2.0	2.1	2.0	2.1	2.0	2.0	2.0	2.0
8.95	2.64	8.95	2.64	8.95	2.24	8.95	2.24
4.44	1.53	4.26	1.68	4.48	1.42	4.25	1.58

Table C9. Electricity Generating Capability
(Gigawatts)

Net Summer Capability[1]	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Electric Generators[2]									
Capability									
Coal Steam	305.1	303.9	302.8	303.8	302.8	317.8	252.8	325.1	255.1
Other Fossil Steam[3]	137.4	124.9	111.6	124.8	112.2	117.4	99.1	115.6	98.8
Combined Cycle	21.0	52.4	107.5	51.6	106.5	107.3	193.2	85.7	171.9
Combustion Turbine/Diesel	86.8	126.4	124.5	126.0	128.4	149.8	137.9	147.7	139.3
Nuclear Power	97.4	97.5	97.5	97.5	97.5	93.7	96.9	97.5	97.5
Pumped Storage	19.3	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Renewable Sources[4]	88.8	94.7	99.2	96.0	99.3	97.9	105.0	99.4	113.5
Distributed Generation[5]	0.0	0.8	0.2	0.7	0.2	2.5	0.9	2.1	0.6
Total	**755.9**	**820.0**	**862.9**	**819.8**	**866.4**	**906.0**	**905.4**	**892.6**	**896.2**
Cumulative Planned Additions[6]									
Coal Steam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Fossil Steam[3]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Combined Cycle	0.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
Combustion Turbine/Diesel	0.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Renewable Sources[4]	0.0	5.1	5.1	5.1	5.1	6.7	6.7	6.7	6.7
Distributed Generation[5]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.0**	**32.0**	**32.0**	**32.0**	**32.0**	**33.7**	**33.7**	**33.7**	**33.7**
Cumulative Unplanned Additions[6]									
Coal Steam	0.0	1.1	0.0	1.0	0.0	18.2	0.0	25.6	0.0
Other Fossil Steam[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combined Cycle	0.0	18.6	73.8	17.8	72.7	73.6	159.6	52.1	138.2
Combustion Turbine/Diesel	0.0	30.9	18.6	30.4	22.4	55.4	32.8	53.9	34.0
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Sources[4]	0.0	0.4	4.9	1.7	5.0	1.9	9.0	3.4	17.6
Distributed Generation[5]	0.0	0.8	0.2	0.7	0.2	2.5	0.9	2.1	0.6
Total	**0.0**	**51.7**	**97.5**	**51.6**	**100.3**	**151.5**	**202.3**	**137.0**	**190.4**
Cumulative Total Additions	**0.0**	**83.7**	**129.5**	**83.6**	**132.3**	**185.2**	**236.0**	**170.7**	**224.1**
Cumulative Retirements[7]									
Coal Steam	0.0	2.3	2.3	2.3	2.3	5.5	52.4	5.6	50.1
Other Fossil Steam[3]	0.0	12.7	26.0	12.8	25.5	20.2	38.5	22.0	38.8
Combined Cycle	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.1
Combustion Turbine/Diesel	0.0	5.5	5.1	5.5	5.0	6.6	5.9	7.2	5.9
Nuclear Power	0.0	0.0	0.0	0.0	0.0	3.7	0.6	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Sources[4]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**0.0**	**20.6**	**33.5**	**20.8**	**33.0**	**36.4**	**97.7**	**35.2**	**95.1**

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
317.9	232.1	325.1	246.8	317.3	224.9	323.9	242.5
116.4	91.1	114.7	96.4	114.9	89.7	111.8	92.8
152.6	236.7	108.8	203.6	199.0	287.3	159.4	252.3
174.4	144.6	174.6	143.5	197.4	146.3	197.1	148.6
81.5	92.9	93.8	96.8	76.3	85.4	87.0	94.8
19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
98.9	107.2	100.4	115.2	99.4	112.5	101.3	118.8
5.8	1.9	4.6	0.9	11.0	3.0	9.1	1.8
967.2	**926.3**	**941.8**	**923.0**	**1035.1**	**969.0**	**1009.4**	**971.3**
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
7.7	7.7	7.7	7.7	8.1	8.1	8.1	8.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34.8	**34.8**	**34.8**	**34.8**	**35.3**	**35.3**	**35.3**	**35.3**
18.8	0.0	26.1	0.0	19.5	0.0	26.1	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
119.0	203.1	75.2	171.2	165.4	253.7	125.8	220.0
80.1	39.6	80.9	38.4	103.1	42.1	103.4	44.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.9	10.2	3.4	18.2	1.9	15.0	3.8	21.3
5.8	1.9	4.6	0.9	11.0	3.0	9.1	1.8
225.5	**254.8**	**190.3**	**228.7**	**300.8**	**313.8**	**268.3**	**287.4**
260.4	**289.7**	**225.1**	**263.5**	**336.1**	**349.1**	**303.6**	**322.7**
6.0	73.0	6.1	58.3	7.3	80.2	7.4	62.6
21.2	46.5	23.0	41.2	22.7	47.9	25.8	44.9
0.2	0.2	0.2	1.4	0.2	0.2	0.2	1.4
6.7	6.0	7.4	6.0	6.7	6.8	7.4	6.9
16.0	4.6	3.6	0.7	21.2	12.1	10.4	2.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
50.3	**130.5**	**40.4**	**107.8**	**58.1**	**147.3**	**51.3**	**118.6**

Table C9. Electricity Generating Capability (Continued)
(Gigawatts)

Net Summer Capability[1]	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Cogenerators[8]									
Capability									
Coal	8.4	8.9	8.9	8.9	8.9	8.6	7.5	8.5	7.5
Petroleum	2.7	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Natural Gas	34.6	39.7	41.8	39.9	42.1	43.1	51.6	43.4	51.4
Other Gaseous Fuels	0.2	0.8	0.8	0.8	0.8	0.9	0.9	0.8	0.8
Renewable Sources[4]	5.4	5.9	5.9	6.1	6.1	6.8	6.8	7.5	7.5
Other	1.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total	**52.4**	**59.1**	**61.1**	**59.5**	**61.7**	**63.1**	**70.6**	**63.9**	**71.0**
Cumulative Additions[6]	**0.0**	**6.7**	**8.7**	**7.1**	**9.3**	**10.7**	**18.1**	**11.5**	**18.6**
Other End-Use Generators[9]									
Renewable Sources[10]	1.0	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3
Cumulative Additions	0.0	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3

[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.
[2]Includes grid-connected utilities and nonutilities except for cogenerators. Includes small power producers and exempt wholesale generators.
[3]Includes oil-, gas-, and dual-fired capability.
[4]Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar and wind power.
[5]Primarily peak-load capacity fueled by natural gas
[6]Cumulative additions after December 31, 1999.
[7]Cumulative total retirements after December 31, 1999.
[8]Nameplate capacity is reported for nonutilities on Form EIA-860B, "Annual Electric Generator Report - Nonutility." Nameplate capacity is designated by the manufacturer. The nameplate capacity has been converted to the net summer capability based on historic relationships.
[9]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. Excludes off-grid photovoltaics and other generators not connected to the distribution or transmission systems.
[10]See Table C17 for more detail.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model estimates and may differ slightly from official EIA data reports. Net summer capability has been estimated for nonutility generators to be consistent with capability for electric utility generators.
Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
8.6	7.3	8.5	7.5	8.6	7.3	8.4	7.4
2.9	2.9	2.9	2.9	2.9	3.0	2.9	2.9
46.9	65.4	46.9	62.9	51.2	83.2	50.5	74.4
1.0	1.0	0.9	0.9	1.1	1.1	0.9	1.0
7.6	7.6	8.9	8.9	8.3	8.3	10.2	10.2
0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
67.9	**85.1**	**68.9**	**83.9**	**73.0**	**103.8**	**73.8**	**96.8**
15.5	**32.7**	**16.4**	**31.5**	**20.5**	**51.4**	**21.4**	**44.4**
1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4

Table C10. Electricity Trade
(Billion Kilowatthours, Unless Otherwise Noted)

Electricity Trade	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Interregional Electricity Trade									
Gross Domestic Firm Power Trade	182.2	125.3	125.3	125.3	125.3	102.9	102.9	102.9	102.9
Gross Domestic Economy Trade	152.1	199.1	150.2	199.2	140.8	154.6	74.8	141.5	83.0
Gross Domestic Trade	**334.3**	**324.4**	**275.5**	**324.5**	**266.1**	**257.5**	**177.7**	**244.4**	**186.0**
Gross Domestic Firm Power Sales (million 1999 dollars)	8588.1	5905.8	5905.8	5905.8	5905.8	4851.2	4851.2	4851.2	4851.2
Gross Domestic Economy Sales (million 1999 dollars)	4204.3	6352.8	6079.4	6083.6	5269.4	4407.4	3472.3	3617.4	3346.2
Gross Domestic Sales (million 1999 dollars)	**12792.4**	**12258.6**	**11985.2**	**11989.4**	**11175.2**	**9258.7**	**8323.6**	**8468.7**	**8197.4**
International Electricity Trade									
Firm Power Imports From Canada and Mexico[1]	27.0	10.7	10.7	10.7	10.7	5.8	17.9	5.8	17.9
Economy Imports From Canada and Mexico[1]	21.9	63.5	63.5	63.5	63.5	45.9	45.9	45.9	45.9
Gross Imports From Canada and Mexico[1]	**48.9**	**74.1**	**74.1**	**74.1**	**74.1**	**51.7**	**63.8**	**51.7**	**63.8**
Firm Power Exports To Canada and Mexico	9.2	9.7	9.7	9.7	9.7	8.7	8.7	8.7	8.7
Economy Exports To Canada and Mexico	6.3	7.0	7.0	7.0	7.0	7.7	7.7	7.7	7.7
Gross Exports To Canada and Mexico	**15.5**	**16.7**	**16.7**	**16.7**	**16.7**	**16.4**	**16.4**	**16.4**	**16.4**

[1]Historically electricity imports were primarily from renewable resources, principally hydroelectric.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports. Firm Power Sales are capacity sales, meaning the delivery of the power is scheduled as part of the normal operating conditions of the affected electric systems. Economy Sales are subject to curtailment or cessation of delivery by the supplier in accordance with prior agreements or under specified conditions.

Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
45.7	45.7	45.7	45.7	0.0	0.0	0.0	0.0
154.5	82.3	137.7	76.9	146.4	84.5	118.3	79.1
200.2	**128.0**	**183.5**	**122.6**	**146.4**	**84.5**	**118.3**	**79.1**
2156.1	2156.1	2156.1	2156.1	0.0	0.0	0.0	0.0
4560.7	3989.1	3496.0	3014.4	4448.7	4308.0	2775.5	2764.1
6716.8	**6145.2**	**5652.1**	**5170.5**	**4448.7**	**4308.0**	**2775.5**	**2764.1**
2.6	14.7	2.6	14.7	0.0	12.1	0.0	12.1
30.8	30.8	30.8	30.8	30.6	30.6	30.6	30.6
33.4	**45.6**	**33.4**	**45.6**	**30.6**	**42.7**	**30.6**	**42.7**
3.9	3.9	3.9	3.9	0.0	0.0	0.0	0.0
7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
11.5	**11.5**	**11.5**	**11.5**	**7.7**	**7.7**	**7.7**	**7.7**

Table C11. Petroleum Supply and Disposition Balance
(Million Barrels per Day, Unless Otherwise Noted)

Supply and Disposition	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Crude Oil									
Domestic Crude Production[1]	5.88	5.69	5.67	5.81	5.79	5.30	5.29	5.54	5.53
Alaska	1.05	0.79	0.79	0.81	0.81	0.65	0.65	0.68	0.68
Lower 48 States	4.83	4.90	4.88	5.00	4.98	4.66	4.64	4.86	4.85
Net Imports	8.61	9.80	9.78	9.72	9.72	10.31	10.29	10.10	10.11
Gross Imports	8.73	9.87	9.84	9.79	9.79	10.36	10.33	10.16	10.16
Exports	0.12	0.07	0.06	0.07	0.07	0.05	0.05	0.06	0.06
Other Crude Supply[2]	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Crude Supply	**14.80**	**15.49**	**15.45**	**15.53**	**15.51**	**15.61**	**15.57**	**15.64**	**15.64**
Natural Gas Plant Liquids	**1.85**	**2.19**	**2.24**	**2.15**	**2.22**	**2.37**	**2.49**	**2.27**	**2.51**
Other Inputs[3]	**0.60**	**0.19**	**0.19**	**0.19**	**0.29**	**0.20**	**0.20**	**0.29**	**0.19**
Refinery Processing Gain[4]	**0.89**	**0.93**	**0.93**	**0.91**	**0.90**	**0.99**	**0.97**	**0.91**	**0.93**
Net Product Imports[5]	**1.30**	**2.25**	**2.07**	**1.95**	**1.69**	**3.44**	**3.30**	**2.52**	**2.41**
Gross Refined Product Imports[6]	1.73	2.45	2.33	2.35	2.12	3.43	3.27	2.78	2.69
Unfinished Oil Imports	0.32	0.56	0.52	0.37	0.36	0.79	0.79	0.54	0.52
Ether Imports	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.82	0.76	0.78	0.78	0.79	0.78	0.77	0.80	0.80
Total Primary Supply[7]	**19.44**	**21.05**	**20.88**	**20.72**	**20.61**	**22.61**	**22.53**	**21.62**	**21.69**
Refined Petroleum Products Supplied									
Motor Gasoline[8]	8.43	9.37	9.35	9.19	9.19	10.06	10.04	9.49	9.50
Jet Fuel[9]	1.67	1.88	1.87	1.88	1.88	2.17	2.17	2.17	2.17
Distillate Fuel[10]	3.54	4.12	4.08	4.03	4.00	4.48	4.41	4.24	4.19
Residual Fuel	0.74	0.64	0.53	0.61	0.52	0.61	0.56	0.57	0.55
Other[11]	5.07	5.09	5.10	5.06	5.08	5.33	5.39	5.19	5.32
Total	**19.46**	**21.10**	**20.93**	**20.77**	**20.66**	**22.64**	**22.57**	**21.67**	**21.73**
Refined Petroleum Products Supplied									
Residential and Commercial	1.10	1.10	1.10	1.08	1.08	1.05	1.06	1.00	1.00
Industrial[12]	5.19	5.22	5.23	5.18	5.20	5.56	5.62	5.40	5.52
Transportation	12.86	14.58	14.54	14.35	14.33	15.92	15.85	15.19	15.16
Electric Generators[13]	0.31	0.19	0.06	0.16	0.05	0.11	0.05	0.09	0.04
Total	**19.46**	**21.10**	**20.93**	**20.77**	**20.66**	**22.64**	**22.57**	**21.67**	**21.73**
Discrepancy[14]	**-0.02**	**-0.05**	**-0.05**	**-0.05**	**-0.05**	**-0.04**	**-0.04**	**-0.05**	**-0.05**
World Oil Price (1999 dollars per barrel)[15]	**17.22**	**20.83**	**20.83**	**20.83**	**20.83**	**21.37**	**21.37**	**21.37**	**21.37**
Import Share of Product Supplied	**0.51**	**0.57**	**0.57**	**0.56**	**0.55**	**0.61**	**0.60**	**0.58**	**0.58**
Net Expenditures for Imported Crude Oil and Petroleum Products (billion 1999 dollars)	**59.74**	**94.30**	**92.78**	**90.92**	**89.00**	**112.23**	**110.94**	**102.40**	**101.64**
Domestic Refinery Distillation Capacity[16]	**16.5**	**16.7**	**16.7**	**16.8**	**16.8**	**16.7**	**16.7**	**16.8**	**16.8**
Capacity Utilization Rate (percent)	**93.0**	**92.6**	**92.5**	**92.2**	**92.2**	**93.3**	**93.3**	**92.9**	**93.0**

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude stock withdrawals minus crude products supplied.
[3]Includes alcohols, ethers, petroleum product stock withdrawals, domestic sources of blending components, and other hydrocarbons.
[4]Represents volumetric gain in refinery distillation and cracking processes.
[5]Includes net imports of finished petroleum products, unfinished oils, other hydrocarbons, alcohols, ethers, and blending components.
[6]Includes blending components.
[7]Total crude supply plus natural gas plant liquids, other inputs, refinery processing gain, and net petroleum imports.
[8]Includes ethanol and ethers blended into gasoline.
[9]Includes naphtha and kerosene types.
[10]Includes distillate and kerosene.
[11]Includes aviation gasoline, liquefied petroleum gas, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, and miscellaneous petroleum products.
[12]Includes consumption by cogenerators.
[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]Balancing item. Includes unaccounted for supply, losses and gains.
[15]Average refiner acquisition cost for imported crude oil.
[16]End-of-year capacity.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 product supplied data from Table C2. Other 1999 data: Energy Information Administration (EIA), *Petroleum Supply Annual 1999,* DOE/EIA-0340(99/1) (Washington, DC, June 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
5.23	5.32	5.55	5.64	5.22	5.36	5.49	5.64
0.70	0.70	0.75	0.75	0.64	0.64	0.69	0.69
4.53	4.61	4.80	4.89	4.58	4.72	4.80	4.95
11.59	11.38	10.72	10.53	11.89	11.81	11.14	11.00
11.64	11.43	10.78	10.60	11.93	11.86	11.19	11.07
0.05	0.05	0.06	0.06	0.05	0.05	0.06	0.06
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.82	**16.70**	**16.27**	**16.17**	**17.11**	**17.17**	**16.62**	**16.65**
2.65	**2.78**	**2.50**	**2.75**	**2.92**	**3.05**	**2.73**	**2.99**
0.21	**0.20**	**0.30**	**0.19**	**0.22**	**0.22**	**0.36**	**0.26**
0.96	**0.95**	**0.91**	**0.94**	**0.98**	**0.97**	**0.88**	**0.91**
3.51	**3.47**	**2.48**	**2.44**	**4.46**	**4.26**	**2.75**	**2.63**
3.51	3.50	2.83	2.81	4.40	4.22	3.10	3.02
0.78	0.75	0.46	0.46	0.89	0.86	0.48	0.46
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.79	0.78	0.82	0.83	0.83	0.81	0.83	0.85
24.14	**24.10**	**22.45**	**22.51**	**25.69**	**25.67**	**23.34**	**23.43**
10.70	10.68	9.66	9.66	11.29	11.27	9.79	9.81
2.52	2.52	2.49	2.49	2.88	2.88	2.82	2.82
4.80	4.75	4.42	4.37	5.12	5.07	4.62	4.57
0.61	0.57	0.56	0.55	0.61	0.58	0.55	0.55
5.55	5.62	5.37	5.48	5.82	5.92	5.59	5.72
24.18	**24.14**	**22.50**	**22.55**	**25.73**	**25.72**	**23.38**	**23.47**
1.03	1.05	0.96	0.97	1.01	1.04	0.92	0.94
5.83	5.90	5.60	5.71	6.15	6.24	5.84	5.97
17.21	17.14	15.87	15.83	18.46	18.39	16.55	16.53
0.11	0.05	0.08	0.04	0.10	0.05	0.07	0.04
24.18	**24.14**	**22.50**	**22.55**	**25.73**	**25.72**	**23.38**	**23.47**
-0.04	**-0.04**	**-0.05**	**-0.05**	**-0.04**	**-0.04**	**-0.04**	**-0.04**
21.89	**21.89**	**21.89**	**21.89**	**22.41**	**22.41**	**22.41**	**22.41**
0.62	**0.62**	**0.59**	**0.58**	**0.64**	**0.62**	**0.59**	**0.58**
128.03	**126.06**	**109.39**	**107.39**	**143.48**	**140.90**	**117.73**	**115.41**
17.9	**17.9**	**17.5**	**17.4**	**18.1**	**18.2**	**17.8**	**17.8**
94.0	**93.6**	**93.0**	**93.0**	**94.7**	**94.7**	**93.6**	**93.7**

Table C12. Petroleum Product Prices
(1999 Cents per Gallon, Unless Otherwise Noted)

Sector and Fuel	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
World Oil Price (1999 dollars per barrel)	**17.22**	**20.83**	**20.83**	**20.83**	**20.83**	**21.37**	**21.37**	**21.37**	**21.37**
Delivered Sector Product Prices									
Residential									
Distillate Fuel	87.0	102.3	102.1	100.9	100.7	105.0	104.9	102.8	102.7
Liquefied Petroleum Gas	89.4	108.9	108.9	108.9	108.7	110.6	112.8	110.8	110.1
Commercial									
Distillate Fuel	60.6	71.7	71.5	70.3	70.2	74.2	73.8	71.9	71.8
Residual Fuel	39.3	54.5	54.0	54.5	54.0	55.5	55.2	55.4	55.2
Residual Fuel (1999 dollars per barrel)	16.53	22.91	22.68	22.88	22.66	23.29	23.19	23.26	23.20
Industrial[1]									
Distillate Fuel	64.5	73.9	73.7	72.6	72.5	76.8	76.3	74.2	74.2
Liquefied Petroleum Gas	73.4	66.9	66.9	66.6	66.6	67.0	69.7	66.8	66.7
Residual Fuel	41.7	50.5	50.0	50.4	50.0	51.4	51.2	51.3	51.2
Residual Fuel (1999 dollars per barrel)	17.50	21.22	21.00	21.19	21.00	21.58	21.49	21.55	21.51
Transportation									
Diesel Fuel (distillate)[2]	114.0	123.3	123.3	122.4	122.2	124.0	123.9	122.9	122.7
Jet Fuel[3]	63.5	70.5	70.6	69.7	69.7	74.1	74.0	72.8	72.5
Motor Gasoline[4]	118.2	134.0	134.4	131.8	131.5	139.6	141.6	133.1	131.7
Liquified Petroleum Gas	111.1	121.4	121.4	122.0	121.7	120.8	123.3	121.5	121.2
Residual Fuel	36.8	46.5	46.3	46.5	46.3	47.6	47.5	47.6	47.5
Residual Fuel (1999 dollars per barrel)	15.45	19.54	19.44	19.53	19.44	19.99	19.95	20.00	19.97
Ethanol (E85)	129.2	171.9	172.1	171.3	171.3	171.2	172.3	169.4	169.5
Methanol (M85)	76.2	96.3	96.7	95.3	95.4	101.2	101.5	94.9	96.6
Electric Generators[5]									
Distillate Fuel	56.4	64.6	66.5	63.3	65.6	67.3	68.0	65.0	66.8
Residual Fuel	35.8	51.3	56.7	51.7	57.8	55.4	61.4	57.9	62.0
Residual Fuel (1999 dollars per barrel)	15.03	21.56	23.80	21.72	24.28	23.26	25.78	24.32	26.03
Refined Petroleum Product Prices[6]									
Distillate Fuel	100.5	111.8	111.9	110.6	110.6	113.7	113.6	111.9	111.8
Jet Fuel[3]	63.5	70.5	70.6	69.7	69.7	74.1	74.0	72.8	72.5
Liquefied Petroleum Gas	76.3	74.7	74.7	74.7	74.6	74.7	77.2	75.0	74.7
Motor Gasoline[4]	118.2	134.0	134.4	131.8	131.5	139.6	141.6	133.1	131.7
Residual Fuel	37.0	48.7	48.3	48.6	48.3	49.9	49.7	49.9	49.8
Residual Fuel (1999 dollars per barrel)	15.54	20.44	20.29	20.42	20.29	20.96	20.88	20.97	20.90
Average	**97.8**	**110.7**	**111.2**	**109.1**	**109.2**	**114.5**	**115.7**	**110.2**	**109.4**

[1]Includes cogenerators. Includes Federal and State taxes while excluding county and state taxes.
[2] Low sulfur diesel fuel. Includes Federal and State taxes while excluding county and local taxes.
[3]Kerosene-type jet fuel.
[4]Sales weighted-average price for all grades. Includes Federal and State taxes while excluding county and local taxes.
[5]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[6]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 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 (99/03-2000/04) (Washington, DC, 1999-2000). 1999 prices for all other petroleum products are derived from EIA, *State Energy Price and Expenditure Report 1997*, DOE/EIA-0376(97) (Washington, DC, July 2000). **Projections**: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
21.89	**21.89**	**21.89**	**21.89**	**22.41**	**22.41**	**22.41**	**22.41**
104.6	104.3	102.2	103.3	107.6	107.3	103.8	104.3
110.8	110.4	107.6	107.9	109.7	109.8	107.8	105.8
73.5	73.1	71.3	72.3	76.5	75.9	72.8	73.3
56.6	56.3	56.5	56.4	57.7	57.5	57.6	57.5
23.77	23.66	23.74	23.68	24.23	24.14	24.21	24.17
76.1	75.8	73.8	74.8	79.2	78.9	75.4	75.9
67.2	67.5	63.2	63.6	66.3	67.0	63.0	61.9
52.5	52.3	52.5	52.4	53.7	53.5	53.7	53.6
22.06	21.98	22.05	22.02	22.54	22.48	22.54	22.52
123.1	122.8	119.8	121.3	122.4	122.4	118.2	118.9
74.8	74.7	74.0	74.0	77.2	77.2	74.3	74.3
133.4	132.7	129.9	130.1	132.0	132.1	127.6	125.5
120.3	120.2	117.8	118.0	117.8	118.3	116.4	114.8
48.7	48.7	48.7	48.7	49.8	49.8	49.8	49.9
20.47	20.44	20.46	20.47	20.93	20.90	20.93	20.94
172.5	172.9	170.9	171.4	173.1	173.8	153.3	151.3
103.9	103.7	102.7	102.7	105.3	105.3	102.7	102.8
67.0	68.2	64.8	67.4	70.1	71.4	66.4	69.6
56.7	62.7	59.6	64.0	58.7	65.0	63.2	67.4
23.80	26.35	25.04	26.88	24.66	27.30	26.55	28.30
113.2	112.9	109.7	111.1	113.7	113.5	109.1	109.8
74.8	74.7	74.0	74.0	77.2	77.2	74.3	74.3
74.5	74.6	71.2	71.7	73.2	73.8	70.9	69.8
133.4	132.7	129.9	130.1	132.0	132.1	127.5	125.5
51.0	50.9	51.0	51.0	52.2	52.1	52.2	52.2
21.43	21.40	21.42	21.42	21.92	21.90	21.92	21.91
111.2	**110.7**	**107.3**	**107.8**	**110.6**	**110.7**	**105.6**	**104.6**

Table C13. Natural Gas Supply and Disposition
(Trillion Cubic Feet per Year)

Supply and Disposition	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Production									
Dry Gas Production[1]	18.67	21.32	21.85	20.91	21.56	23.36	24.63	22.40	24.87
Supplemental Natural Gas[2]	0.10	0.11	0.11	0.11	0.11	0.06	0.06	0.06	0.06
Net Imports	**3.38**	**4.70**	**4.66**	**4.66**	**4.56**	**5.01**	**6.61**	**4.79**	**5.14**
Canada	3.29	4.49	4.45	4.45	4.35	4.72	4.99	4.53	4.85
Mexico	-0.01	-0.18	-0.18	-0.18	-0.18	-0.25	0.32	-0.25	-0.25
Liquefied Natural Gas	0.10	0.39	0.39	0.39	0.39	0.53	1.30	0.51	0.54
Total Supply	**22.15**	**26.14**	**26.63**	**25.69**	**26.24**	**28.42**	**31.29**	**27.24**	**30.06**
Consumption by Sector									
Residential	4.75	5.40	5.41	5.27	5.28	5.39	5.32	5.15	5.06
Commercial	3.06	3.89	3.88	3.90	3.90	4.08	4.01	4.11	4.04
Industrial[3]	8.31	8.78	8.78	8.74	8.73	9.48	9.48	9.48	9.38
Electric Generators[4]	3.76	5.44	5.88	5.17	5.67	6.83	9.70	5.89	8.75
Lease and Plant Fuel[5]	1.23	1.36	1.39	1.34	1.37	1.50	1.56	1.45	1.57
Pipeline Fuel	0.64	0.80	0.82	0.79	0.81	0.88	0.94	0.85	0.94
Transportation[6]	0.02	0.05	0.05	0.07	0.07	0.09	0.09	0.13	0.12
Total	**21.77**	**25.73**	**26.21**	**25.28**	**25.83**	**28.24**	**31.09**	**27.04**	**29.86**
Discrepancy[7]	**0.38**	**0.41**	**0.41**	**0.41**	**0.41**	**0.19**	**0.21**	**0.20**	**0.20**

[1]Marketed production (wet) minus extraction losses.
[2]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
[3]Includes consumption by cogenerators.
[4]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[5]Represents natural gas used in the field gathering and processing plant machinery.
[6]Compressed natural gas used as vehicle fuel.
[7]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems which vary in scope, format, definition, and respondent type. In addition, 1999 values include net storage injections.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 supplemental natural gas: Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). 1999 transportation sector consumption: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. Other 1999 consumption: EIA, *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf with adjustments to end-use sector consumption levels for consumption of natural gas by electric wholesale generators based on EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
26.50	27.78	24.97	27.56	29.34	30.66	27.34	30.13
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5.44	**7.42**	**4.96**	**5.48**	**5.78**	**7.86**	**5.12**	**5.61**
5.12	5.40	4.68	5.17	5.39	5.70	4.82	5.26
-0.33	0.35	-0.33	-0.33	-0.40	0.36	-0.40	-0.40
0.65	1.68	0.61	0.64	0.79	1.80	0.71	0.75
32.00	**35.26**	**29.99**	**33.10**	**35.17**	**38.57**	**32.52**	**35.79**
5.63	5.58	5.30	5.23	5.92	5.85	5.52	5.45
4.24	4.29	4.31	4.31	4.36	4.55	4.46	4.56
10.03	10.25	9.96	10.05	10.52	10.94	10.31	10.56
9.12	12.05	7.54	10.41	11.15	13.87	9.11	11.86
1.68	1.74	1.61	1.73	1.86	1.92	1.76	1.89
0.98	1.03	0.92	1.02	1.07	1.13	0.99	1.10
0.13	0.12	0.18	0.17	0.15	0.15	0.21	0.21
31.81	**35.07**	**29.81**	**32.93**	**35.03**	**38.40**	**32.36**	**35.62**
0.18	**0.19**	**0.18**	**0.18**	**0.15**	**0.17**	**0.16**	**0.17**

Table C14. Natural Gas Prices, Margins, and Revenue
(1999 Dollars per Thousand Cubic Feet, Unless Otherwise Noted)

Prices, Margins, and Revenue	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Source Price									
Average Lower 48 Wellhead Price[1]	2.08	2.99	3.01	2.86	2.87	2.82	3.41	2.39	2.95
Average Import Price	2.29	2.99	3.07	2.95	3.01	2.66	2.97	2.54	2.82
Average[2]	**2.11**	**2.99**	**3.02**	**2.88**	**2.89**	**2.79**	**3.32**	**2.42**	**2.93**
Delivered Prices									
Residential	6.69	7.33	7.37	7.24	7.26	6.88	7.42	6.55	7.07
Commercial	5.49	5.72	5.77	5.60	5.63	5.78	6.32	5.41	5.92
Industrial[3]	2.87	3.76	3.81	3.65	3.67	3.55	4.13	3.15	3.70
Electric Generators[4]	2.62	3.49	3.77	3.37	3.62	3.30	4.18	2.87	3.70
Transportation[5]	7.21	7.50	7.54	7.80	7.82	7.36	7.91	7.64	8.17
Average[6]	**4.14**	**4.85**	**4.93**	**4.75**	**4.80**	**4.55**	**5.09**	**4.19**	**4.68**
Transmission & Distribution Margins[7]									
Residential	4.58	4.34	4.35	4.36	4.37	4.09	4.10	4.13	4.14
Commercial	3.37	2.73	2.74	2.73	2.74	2.99	3.00	2.99	3.00
Industrial[3]	0.76	0.78	0.79	0.77	0.78	0.76	0.81	0.73	0.78
Electric Generators[4]	0.51	0.50	0.75	0.49	0.73	0.51	0.87	0.45	0.77
Transportation[5]	5.10	4.52	4.52	4.92	4.93	4.57	4.60	5.22	5.24
Average[6]	**2.03**	**1.87**	**1.91**	**1.87**	**1.91**	**1.76**	**1.77**	**1.77**	**1.75**
Transmission & Distribution Revenue (billion 1999 dollars)									
Residential	21.77	23.45	23.52	22.99	23.06	22.07	21.81	21.24	20.98
Commercial	10.32	10.62	10.65	10.64	10.67	12.19	12.02	12.28	12.10
Industrial[3]	6.28	6.82	6.92	6.77	6.80	7.20	7.72	6.94	7.29
Electric Generators[4]	1.90	2.74	4.38	2.55	4.11	3.46	8.41	2.63	6.75
Transportation[5]	0.08	0.24	0.24	0.36	0.36	0.40	0.40	0.66	0.65
Total	**40.35**	**43.87**	**45.71**	**43.31**	**45.00**	**45.33**	**50.36**	**43.75**	**47.78**

[1]Represents lower 48 onshore and offshore supplies.
[2]Quantity-weighted average of the average lower 48 wellhead price and the average price of imports at the U.S. border.
[3]Includes consumption by cogenerators.
[4]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[5]Compressed natural gas used as a vehicle fuel. Price includes estimated motor vehicle fuel taxes.
[6]Weighted average prices and margins. Weights used are the sectoral consumption values excluding lease, plant, and pipeline fuel.
[7]Within the table, "transmission and distribution" margins equal the difference between the delivered price and the source price (average of the wellhead price and the price of imports at the U.S. border) of natural gas and, thus, reflect the total cost of bringing natural gas to market. When the term "transmission and distribution" margins is used in today's natural gas market, it generally does not include the cost of independent natural gas marketers or costs associated with aggregation of supplies, provisions of storage, and other services. As used here, the term includes the cost of all services and the cost of pipeline fuel used in compressor stations.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 industrial delivered prices based on Energy Information Administration (EIA), *Manufacturing Energy Consumption Survey 1994*. 1999 residential and commercial delivered prices, average lower 48 wellhead price, and average import price: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). **Other 1999 values and projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
2.92	3.35	2.30	2.73	3.10	3.72	2.20	2.60
2.65	2.91	2.45	2.74	2.71	3.04	2.44	2.71
2.87	**3.25**	**2.33**	**2.73**	**3.03**	**3.58**	**2.24**	**2.62**
6.77	7.19	6.23	6.68	6.74	7.31	5.94	6.38
5.76	6.17	5.17	5.61	5.82	6.38	4.97	5.40
3.66	4.07	3.05	3.51	3.84	4.44	2.96	3.39
3.46	4.12	2.78	3.51	3.68	4.52	2.75	3.44
7.48	7.88	7.63	8.06	7.50	8.05	7.42	7.84
4.52	**4.93**	**3.96**	**4.39**	**4.61**	**5.22**	**3.79**	**4.22**
3.90	3.93	3.90	3.95	3.71	3.73	3.70	3.76
2.89	2.91	2.84	2.89	2.79	2.80	2.73	2.78
0.78	0.81	0.72	0.78	0.81	0.86	0.71	0.77
0.58	0.87	0.45	0.78	0.66	0.94	0.51	0.81
4.60	4.63	5.30	5.33	4.47	4.47	5.18	5.22
1.65	**1.68**	**1.63**	**1.66**	**1.59**	**1.64**	**1.55**	**1.60**
21.94	21.95	20.68	20.66	21.95	21.81	20.42	20.50
12.25	12.48	12.25	12.45	12.16	12.71	12.17	12.68
7.85	8.33	7.14	7.82	8.50	9.36	7.37	8.13
5.32	10.47	3.39	8.15	7.33	13.05	4.63	9.66
0.58	0.56	0.94	0.92	0.68	0.66	1.11	1.08
47.93	**53.79**	**44.39**	**50.00**	**50.61**	**57.59**	**45.70**	**52.06**

Table C15. Oil and Gas Supply

Production and Supply	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Crude Oil									
Lower 48 Average Wellhead Price[1] (1999 dollars per barrel)	**16.49**	**20.48**	**20.57**	**20.52**	**20.56**	**20.80**	**20.79**	**20.83**	**20.78**
Production (million barrels per day)[2]									
U.S. Total	**5.88**	**5.69**	**5.67**	**5.81**	**5.79**	**5.30**	**5.29**	**5.54**	**5.53**
Lower 48 Onshore	3.27	2.80	2.81	2.83	2.83	2.50	2.51	2.58	2.60
Conventional	2.59	2.18	2.17	2.17	2.17	1.81	1.83	1.82	1.85
Enhanced Oil Recovery	0.68	0.62	0.64	0.66	0.66	0.69	0.68	0.76	0.75
Lower 48 Offshore	1.56	2.09	2.07	2.17	2.16	2.16	2.13	2.28	2.25
Alaska	1.05	0.79	0.79	0.81	0.81	0.65	0.65	0.68	0.68
Lower 48 End of Year Reserves[2] (billion barrels)	**18.33**	**15.76**	**15.77**	**16.11**	**16.07**	**14.43**	**14.52**	**15.05**	**15.12**
Natural Gas									
Lower 48 Average Wellhead Price[1] (1999 dollars per thousand cubic feet)	**2.08**	**2.99**	**3.01**	**2.86**	**2.87**	**2.82**	**3.41**	**2.39**	**2.95**
Dry Production (trillion cubic feet)[3]									
U.S. Total	**18.67**	**21.32**	**21.85**	**20.91**	**21.56**	**23.36**	**24.63**	**22.40**	**24.87**
Lower 48 Onshore	12.83	14.37	14.61	14.06	14.47	16.42	17.51	15.99	17.64
Associated-Dissolved[4]	1.80	1.51	1.51	1.51	1.51	1.32	1.33	1.33	1.34
Non-Associated	11.03	12.86	13.10	12.55	12.96	15.10	16.18	14.67	16.30
Conventional	6.64	7.62	7.85	7.36	7.62	7.79	8.30	7.59	8.14
Unconventional	4.39	5.24	5.25	5.19	5.34	7.30	7.88	7.08	8.16
Lower 48 Offshore	5.43	6.49	6.77	6.39	6.63	6.44	6.62	5.90	6.73
Associated-Dissolved[4]	0.93	1.06	1.06	1.08	1.08	1.09	1.09	1.12	1.11
Non-Associated	4.50	5.42	5.71	5.31	5.55	5.35	5.53	4.78	5.62
Alaska	0.42	0.47	0.46	0.46	0.46	0.50	0.50	0.50	0.50
Lower 48 End of Year Dry Reserves[3] (trillion cubic feet)	**157.41**	**169.38**	**169.60**	**174.03**	**175.26**	**184.15**	**188.06**	**192.10**	**200.74**
Supplemental Gas Supplies[5] (trillion cubic feet)	**0.10**	**0.11**	**0.11**	**0.11**	**0.11**	**0.06**	**0.06**	**0.06**	**0.06**
Total Lower 48 Wells (thousands)	**17.93**	**29.02**	**28.84**	**28.52**	**28.55**	**29.30**	**33.89**	**26.05**	**32.32**

[1]Represents lower 48 onshore and offshore supplies.
[2]Includes lease condensate.
[3]Marketed production (wet) minus extraction losses.
[4]Gas which occurs in crude oil reserves either as free gas (associated) or as gas in solution with crude oil (dissolved).
[5]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 lower 48 onshore, lower 48 offshore, and Alaska crude oil production: Energy Information Administration (EIA), *Petroleum Supply Annual 1999,* DOE/EIA-0340(99/1) (Washington, DC, June 2000). 1999 natural gas lower 48 average wellhead price, Alaska and total natural gas production, and supplemental gas supplies: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). Other 1999 values: EIA, Office of Integrated Analysis and Forecasting. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
21.16	**21.21**	**21.04**	**21.07**	**21.50**	**21.44**	**21.57**	**21.56**
5.23	**5.32**	**5.55**	**5.64**	**5.22**	**5.36**	**5.49**	**5.64**
2.56	2.59	2.71	2.75	2.71	2.80	2.87	2.95
1.77	1.82	1.82	1.88	1.96	2.04	2.05	2.13
0.79	0.76	0.89	0.87	0.74	0.76	0.82	0.82
1.98	2.02	2.09	2.14	1.88	1.92	1.92	2.00
0.70	0.70	0.75	0.75	0.64	0.64	0.69	0.69
13.99	**14.20**	**14.81**	**15.06**	**14.01**	**14.32**	**14.59**	**15.03**
2.92	**3.35**	**2.30**	**2.73**	**3.10**	**3.72**	**2.20**	**2.60**
26.50	**27.78**	**24.97**	**27.56**	**29.34**	**30.66**	**27.34**	**30.13**
19.04	19.97	18.26	20.36	21.10	22.34	20.76	23.19
1.30	1.33	1.32	1.35	1.38	1.43	1.42	1.46
17.74	18.64	16.95	19.01	19.72	20.92	19.34	21.73
9.54	9.52	9.28	9.64	11.05	11.35	11.01	11.23
8.20	9.12	7.67	9.37	8.66	9.57	8.34	10.50
6.92	7.28	6.18	6.68	7.66	7.75	6.02	6.38
1.06	1.07	1.09	1.09	1.04	1.05	1.05	1.07
5.86	6.21	5.09	5.58	6.63	6.71	4.97	5.31
0.54	0.53	0.53	0.53	0.57	0.56	0.56	0.56
195.05	**202.68**	**210.56**	**226.28**	**199.35**	**203.85**	**221.89**	**239.96**
0.06	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
32.27	**34.32**	**29.15**	**35.11**	**38.07**	**43.80**	**31.57**	**35.76**

Table C16. Coal Supply, Disposition, and Prices
(Million Short Tons per Year, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Production[1]									
Appalachia	434	432	356	421	354	425	267	406	270
Interior	182	185	140	184	142	183	113	187	118
West	486	612	534	616	539	681	403	677	412
East of the Mississippi	558	569	466	557	468	564	374	547	382
West of the Mississippi	544	659	564	664	567	725	409	724	417
Total	**1102**	**1228**	**1030**	**1222**	**1035**	**1289**	**783**	**1271**	**800**
Net Imports									
Imports	9	16	12	16	12	17	9	17	9
Exports	58	60	60	60	60	58	59	58	60
Total	**-49**	**-44**	**-48**	**-44**	**-48**	**-40**	**-50**	**-41**	**-51**
Total Supply[2]	**1053**	**1184**	**982**	**1177**	**987**	**1249**	**733**	**1231**	**749**
Consumption by Sector									
Residential and Commercial	5	5	5	5	5	5	5	5	5
Industrial[3]	79	82	83	82	82	83	82	82	80
Coke Plants	28	25	25	25	25	23	23	22	22
Electric Generators[4]	920	1073	870	1067	875	1139	623	1125	644
Total	**1031**	**1185**	**983**	**1179**	**987**	**1250**	**733**	**1233**	**751**
Discrepancy and Stock Change[5]	**21**	**-1**	**-1**	**-1**	**-0**	**-1**	**-0**	**-2**	**-2**
Average Minemouth Price									
(1999 dollars per short ton)	17.13	15.22	14.47	14.30	13.77	14.19	14.63	12.73	13.40
(1999 dollars per million Btu)	0.82	0.74	0.69	0.69	0.66	0.69	0.68	0.62	0.62
Delivered Prices[6] **(1999 dollars per short ton)**									
Industrial	31.37	29.65	28.57	28.64	27.71	28.56	26.05	26.79	24.68
Coke Plants	44.38	42.40	42.56	40.95	41.27	41.25	41.59	38.97	39.25
Electric Generators									
(1999 dollars per short ton)	24.69	22.92	21.25	22.09	20.66	21.26	20.40	19.73	19.50
(1999 dollars per million Btu)	1.21	1.13	1.05	1.10	1.01	1.06	0.98	0.98	0.93
Average	**25.74**	**23.80**	**22.42**	**22.94**	**21.77**	**22.11**	**21.69**	**20.54**	**20.63**
Exports[7]	37.50	36.41	35.96	35.06	34.73	35.57	34.32	33.40	32.43

[1]Includes anthracite, bituminous coal, lignite, and waste coal delivered to independent power producers. Waste coal deliveries totaled 8.5 million tons in 1995, 8.8 million tons in 1996, 8.1 million tons in 1997, 8.6 million tons in 1998, and are projected to reach 9.6 million tons in 1999, and 12.2 million tons in 2000.
[2]Production plus net imports and net storage withdrawals.
[3]Includes consumption by cogenerators.
[4]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[5]Balancing item: the sum of production, net imports, and net storage minus total consumption.
[6]Sectoral prices weighted by consumption tonnage; weighted average excludes residential/ commercial prices and export free-alongside-ship (f.a.s.) prices.
[7]F.a.s. price at U.S. port of exit.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 data based on Energy Information Administration (EIA), *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000) and EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
404	246	392	247	396	227	375	228
171	105	175	115	164	92	177	113
742	372	715	395	775	360	719	375
536	345	526	357	526	313	513	336
782	378	755	401	810	366	758	380
1317	**723**	**1282**	**758**	**1336**	**679**	**1271**	**716**
18	9	18	9	20	9	20	9
56	60	57	60	56	64	56	61
-37	**-51**	**-39**	**-51**	**-36**	**-55**	**-36**	**-52**
1280	**671**	**1243**	**706**	**1300**	**624**	**1234**	**664**
5	5	5	5	5	5	5	5
84	83	82	81	85	86	81	81
21	21	19	19	19	19	17	17
1172	562	1138	602	1190	515	1133	563
1282	**671**	**1245**	**707**	**1299**	**625**	**1236**	**666**
-2	**0**	**-2**	**-1**	**1**	**-1**	**-2**	**-2**
13.40	13.58	11.63	12.01	12.93	12.61	10.76	10.97
0.66	0.63	0.57	0.56	0.64	0.59	0.53	0.51
27.43	24.63	25.13	23.00	26.49	23.32	23.41	21.34
39.93	39.90	36.61	36.74	38.50	38.68	34.36	34.47
20.24	18.77	18.42	17.53	19.34	17.28	16.94	16.10
1.02	0.91	0.92	0.84	0.98	0.84	0.85	0.78
21.03	**20.16**	**19.14**	**18.69**	**20.09**	**18.76**	**17.61**	**17.22**
34.66	32.44	31.36	29.96	33.07	31.01	29.32	28.32

Table C17. Renewable Energy Generating Capability and Generation
(Gigawatts, Unless Otherwise Noted)

Capacity and Generation	1999	Projections 2005 Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	2010 Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Electric Generators[1]									
(excluding cogenerators)									
Net Summer Capability									
Conventional Hydropower	78.77	79.26	79.34	79.26	79.26	79.38	79.85	79.38	79.62
Geothermal[2]	2.87	3.36	7.34	4.35	6.49	4.81	9.29	5.63	8.20
Municipal Solid Waste[3]	2.61	2.96	3.41	3.22	3.54	3.42	4.30	3.66	4.29
Wood and Other Biomass[4]	1.57	1.75	1.80	1.75	1.75	2.12	3.20	2.12	2.34
Solar Thermal	0.33	0.35	0.35	0.35	0.35	0.40	0.40	0.40	0.40
Solar Photovoltaic	0.01	0.08	0.08	0.08	0.08	0.21	0.21	0.21	0.21
Wind	2.66	6.92	6.92	6.96	7.83	7.52	7.74	7.97	18.48
Total	**88.83**	**94.68**	**99.24**	**95.98**	**99.32**	**97.85**	**104.99**	**99.36**	**113.54**
Generation (billion kilowatthours)									
Conventional Hydropower	309.55	301.20	301.46	301.19	301.17	301.13	302.65	301.10	301.90
Geothermal[2]	13.21	17.71	50.68	25.91	43.60	29.92	66.90	36.71	57.85
Municipal Solid Waste[3]	18.12	20.68	24.25	22.74	25.29	23.88	30.79	25.71	30.67
Wood and Other Biomass[4]	8.76	14.92	60.96	15.38	40.63	21.22	71.16	17.10	64.83
Dedicated Plants	7.73	9.17	9.51	9.17	9.20	11.36	18.65	11.35	12.90
Cofiring	1.03	5.75	51.44	6.21	31.43	9.86	52.51	5.75	51.93
Solar Thermal	0.89	0.96	0.96	0.96	0.96	1.11	1.11	1.11	1.11
Solar Photovoltaic	0.03	0.20	0.20	0.20	0.20	0.51	0.51	0.51	0.51
Wind	4.61	16.30	16.30	16.47	19.39	18.16	18.78	19.79	57.83
Total	**355.16**	**371.97**	**454.80**	**382.85**	**431.24**	**395.92**	**491.89**	**402.02**	**514.70**
Cogenerators[5]									
Net Summer Capability									
Municipal Solid Waste	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Biomass	4.65	5.19	5.17	5.44	5.43	6.09	6.06	6.82	6.82
Total	**5.35**	**5.89**	**5.87**	**6.14**	**6.13**	**6.79**	**6.76**	**7.52**	**7.52**
Generation (billion kilowatthours)									
Municipal Solid Waste	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
Biomass	27.08	30.04	29.89	31.49	31.41	35.20	34.94	39.44	39.36
Total	**31.12**	**34.08**	**33.94**	**35.54**	**35.45**	**39.24**	**38.99**	**43.49**	**43.40**
Other End-Use Generators[6]									
Net Summer Capability									
Conventional Hydropower[7]	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar Photovoltaic	0.01	0.10	0.10	0.10	0.10	0.35	0.35	0.35	0.35
Total	**1.00**	**1.09**	**1.09**	**1.09**	**1.09**	**1.34**	**1.34**	**1.34**	**1.34**
Generation (billion kilowatthours)									
Conventional Hydropower[7]	4.57	4.44	4.44	4.44	4.44	4.43	4.43	4.43	4.43
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar Photovoltaic	0.02	0.20	0.20	0.20	0.20	0.75	0.75	0.75	0.75
Total	**4.59**	**4.64**	**4.64**	**4.64**	**4.64**	**5.18**	**5.18**	**5.18**	**5.18**

[1]Includes grid-connected utilities and nonutilities other than cogenerators. These nonutility facilities include 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. Excludes off-grid photovoltaics and other generators not connected to the distribution or transmission systems.
[7]Represents own-use industrial hydroelectric power.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports. Net summer capability has been estimated for nonutility generators for AEO2001. 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: 1999 electric utility capability: Energy Information Administration (EIA), Form EIA-860A: "Annual Electric Generator Report - Utility." 1999 nonutility and cogenerator capability: EIA, Form EIA-860B: "Annual Electric Generator Report - Nonutility." 1999 generation: EIA, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
79.38	79.85	79.38	79.62	79.38	79.85	79.38	79.62
4.83	9.67	5.63	8.23	4.83	9.93	5.63	8.23
3.79	4.68	4.02	4.66	3.93	4.83	4.17	4.80
2.40	4.03	2.40	2.62	2.45	5.49	2.45	2.72
0.44	0.44	0.44	0.44	0.48	0.48	0.48	0.48
0.37	0.37	0.37	0.37	0.54	0.54	0.54	0.54
7.72	8.14	8.19	19.31	7.74	11.35	8.62	22.37
98.92	**107.18**	**100.43**	**115.24**	**99.35**	**112.47**	**101.27**	**118.76**
300.57	302.08	300.53	301.32	300.06	301.54	300.00	300.78
30.10	70.07	36.74	58.06	30.13	72.25	36.76	58.08
26.72	33.73	28.54	33.50	27.76	34.77	29.58	34.54
22.27	71.62	19.62	63.78	19.29	76.74	17.62	55.48
13.47	24.40	13.46	15.01	13.82	34.19	13.80	15.71
8.79	47.22	6.17	48.77	5.47	42.55	3.82	39.78
1.24	1.24	1.24	1.24	1.37	1.37	1.37	1.37
0.92	0.92	0.92	0.92	1.36	1.36	1.36	1.36
18.67	19.90	20.41	60.56	18.77	30.48	22.12	71.96
400.49	**499.55**	**408.00**	**519.38**	**398.74**	**518.50**	**408.81**	**523.56**
0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
6.90	6.87	8.19	8.18	7.59	7.56	9.51	9.50
7.60	**7.57**	**8.89**	**8.88**	**8.29**	**8.26**	**10.21**	**10.20**
4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
39.84	39.56	47.41	47.26	43.82	43.53	55.14	55.00
43.88	**43.60**	**51.46**	**51.31**	**47.87**	**47.58**	**59.19**	**59.05**
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.35	0.35	0.35	0.36	0.35	0.35	0.35	0.39
1.34	**1.34**	**1.34**	**1.35**	**1.34**	**1.34**	**1.34**	**1.38**
4.42	4.42	4.42	4.42	4.41	4.41	4.41	4.41
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.75	0.75	0.76	0.77	0.75	0.76	0.76	0.85
5.18	**5.18**	**5.18**	**5.19**	**5.17**	**5.17**	**5.17**	**5.26**

Table C18. Renewable Energy Consumption by Sector and Source[1]
(Quadrillion Btu per Year)

Sector and Source	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Marketed Renewable Energy[2]									
Residential	**0.41**	**0.42**	**0.42**	**0.40**	**0.40**	**0.42**	**0.42**	**0.39**	**0.38**
Wood	0.41	0.42	0.42	0.40	0.40	0.42	0.42	0.39	0.38
Commercial	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Biomass	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Industrial[3]	**2.15**	**2.40**	**2.40**	**2.48**	**2.47**	**2.63**	**2.62**	**2.81**	**2.81**
Conventional Hydroelectric	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Municipal Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	1.97	2.22	2.21	2.29	2.29	2.44	2.44	2.62	2.62
Transportation	**0.12**	**0.20**	**0.20**	**0.20**	**0.20**	**0.21**	**0.21**	**0.21**	**0.21**
Ethanol used in E85[4]	0.00	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04
Ethanol used in Gasoline Blending	0.12	0.18	0.18	0.17	0.17	0.19	0.19	0.18	0.18
Electric Generators[5]	**3.88**	**4.17**	**5.68**	**4.46**	**5.32**	**4.70**	**6.42**	**4.91**	**6.46**
Conventional Hydroelectric	3.19	3.10	3.10	3.10	3.10	3.10	3.11	3.10	3.11
Geothermal	0.28	0.42	1.42	0.69	1.22	0.82	1.93	1.03	1.67
Municipal Solid Waste[6]	0.25	0.28	0.33	0.31	0.34	0.32	0.42	0.35	0.42
Biomass	0.11	0.18	0.65	0.19	0.44	0.25	0.75	0.21	0.70
Dedicated Plants	0.10	0.11	0.10	0.11	0.10	0.14	0.20	0.14	0.14
Cofiring	0.01	0.07	0.54	0.07	0.34	0.12	0.56	0.07	0.56
Solar Thermal	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Solar Photovoltaic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind	0.05	0.17	0.17	0.17	0.20	0.19	0.19	0.20	0.55
Total Marketed Renewable Energy	**6.64**	**7.27**	**8.78**	**7.62**	**8.47**	**8.05**	**9.76**	**8.40**	**9.95**
Non-Marketed Renewable Energy[7]									
Selected Consumption									
Residential	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Solar Hot Water Heating	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Geothermal Heat Pumps	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Solar Photovoltaic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**
Solar Thermal	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Solar Photovoltaic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ethanol									
From Corn	0.12	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.18
From Cellulose	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03
Total	**0.12**	**0.20**	**0.20**	**0.20**	**0.20**	**0.21**	**0.21**	**0.21**	**0.21**

[1]Actual heat rates used to determine fuel consumption for all renewable fuels except hydropower, solar, and wind. Consumption at hydroelectric, solar, and wind facilities determined by using the fossil fuel equivalent of 10,280 Btu per kilowatthour.

[2]Includes nonelectric renewable energy groups for which the energy source is bought and sold in the marketplace, although all transactions may not necessarily be marketed, and marketed renewable energy inputs for electricity entering the marketplace on the electric power grid. Excludes electricity imports; see Table C8.

[3]Includes all electricity production by industrial and other cogenerators for the grid and for own use.

[4]Excludes motor gasoline component of E85.

[5]Includes renewable energy delivered to the grid from electric utilities and nonutilities. Renewable energy used in generating electricity for own use is included in the individual sectoral electricity energy consumption values.

[6]Includes landfill gas.

[7]Includes selected renewable energy consumption data for which the energy is not bought or sold, either directly or indirectly as an input to marketed energy. The Energy Information Administration does not estimate or project total consumption of nonmarketed renewable energy.

Btu = British thermal unit.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.

Sources: 1999 ethanol: Energy Information Administration (EIA), *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). 1999 electric generators: EIA, Form EIA-860A: "Annual Electric Generator Report - Utility" and Form EIA-860B: "Annual Electric Generator Report - Nonutility." Other 1999: EIA, Office of Integrated Analysis and Forecasting. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
0.43	**0.42**	**0.38**	**0.37**	**0.43**	**0.43**	**0.38**	**0.37**
0.43	0.42	0.38	0.37	0.43	0.43	0.38	0.37
0.08	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
2.85	**2.85**	**3.17**	**3.17**	**3.07**	**3.07**	**3.55**	**3.55**
0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.67	2.66	2.98	2.98	2.89	2.89	3.36	3.36
0.23	**0.22**	**0.22**	**0.22**	**0.24**	**0.24**	**0.31**	**0.31**
0.03	0.03	0.05	0.05	0.03	0.03	0.06	0.06
0.19	0.19	0.17	0.17	0.21	0.21	0.25	0.25
4.76	**6.59**	**4.98**	**6.53**	**4.75**	**6.82**	**5.00**	**6.57**
3.09	3.11	3.09	3.10	3.08	3.10	3.08	3.09
0.82	2.03	1.03	1.68	0.82	2.10	1.03	1.68
0.36	0.46	0.39	0.46	0.38	0.47	0.40	0.47
0.27	0.76	0.24	0.69	0.24	0.80	0.23	0.61
0.17	0.26	0.17	0.16	0.17	0.36	0.18	0.17
0.11	0.50	0.08	0.53	0.07	0.44	0.05	0.44
0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.19	0.20	0.21	0.57	0.19	0.31	0.23	0.69
8.35	**10.17**	**8.83**	**10.37**	**8.58**	**10.64**	**9.31**	**10.88**
0.04	**0.03**	**0.04**	**0.04**	**0.04**	**0.03**	**0.04**	**0.04**
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.19	0.19	0.15	0.15	0.17	0.17	0.11	0.11
0.04	0.04	0.07	0.07	0.07	0.07	0.20	0.20
0.23	**0.22**	**0.22**	**0.22**	**0.24**	**0.24**	**0.31**	**0.31**

Table C19. Carbon Dioxide Emissions by Sector and Source
(Million Metric Tons Carbon Equivalent per Year)

Sector and Source	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Residential									
Petroleum	26.0	26.6	26.6	25.8	25.8	24.6	24.7	22.8	23.0
Natural Gas	69.5	79.9	80.0	78.0	78.1	79.8	78.6	76.1	74.9
Coal	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.2	1.2
Electricity	193.4	226.8	190.9	224.4	191.9	240.3	165.1	234.0	166.2
Total	**290.1**	**334.5**	**298.8**	**329.3**	**297.0**	**346.0**	**269.7**	**334.2**	**265.2**
Commercial									
Petroleum	13.7	11.9	11.9	11.9	11.8	12.1	12.3	11.9	12.0
Natural Gas	45.4	57.5	57.4	57.6	57.6	60.3	59.3	60.8	59.7
Coal	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8
Electricity	181.3	219.0	184.1	216.3	185.0	241.0	166.7	234.1	167.6
Total	**242.1**	**290.1**	**255.1**	**287.6**	**256.2**	**315.1**	**240.1**	**308.6**	**241.2**
Industrial[1]									
Petroleum	104.2	98.8	99.0	97.6	98.2	104.6	106.1	99.2	103.2
Natural Gas[2]	141.6	147.7	148.1	146.8	147.1	159.5	160.8	159.1	159.4
Coal	55.9	65.6	65.7	64.3	64.5	65.4	64.5	62.4	61.6
Electricity	178.8	192.9	162.7	189.3	161.6	203.7	139.7	194.4	137.4
Total	**480.4**	**505.0**	**475.5**	**498.0**	**471.4**	**533.2**	**471.1**	**515.1**	**461.6**
Transportation									
Petroleum[3]	485.8	554.7	553.2	545.7	544.8	606.2	603.2	578.1	576.9
Natural Gas[4]	9.5	12.6	12.9	12.7	13.1	14.3	15.1	14.4	15.8
Other[5]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Electricity	2.9	4.4	3.8	3.7	3.2	5.8	4.2	4.4	3.3
Total[3]	**498.2**	**571.8**	**569.9**	**562.1**	**561.1**	**626.3**	**622.6**	**597.0**	**596.1**
Total Carbon Dioxide Emissions by Delivered Fuel									
Petroleum[3]	629.7	692.0	690.6	681.0	680.6	747.4	746.2	712.0	715.2
Natural Gas	266.0	297.8	298.4	295.1	295.9	313.9	313.8	310.4	309.8
Coal	58.8	68.5	68.7	67.2	67.4	68.6	67.7	65.4	64.6
Other[5]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Electricity	556.3	643.1	541.5	633.7	541.7	690.7	475.8	667.0	474.5
Total[3]	**1510.8**	**1701.4**	**1599.3**	**1677.0**	**1585.6**	**1820.6**	**1603.6**	**1754.9**	**1564.1**
Electric Generators[6]									
Petroleum	20.0	9.1	2.7	7.7	2.5	5.3	2.2	4.0	2.0
Natural Gas	45.8	79.8	86.3	75.9	83.2	100.2	142.3	86.4	128.4
Coal	490.5	554.2	452.5	550.1	456.1	585.3	331.3	576.6	344.1
Total	**556.3**	**643.1**	**541.5**	**633.7**	**541.7**	**690.7**	**475.8**	**667.0**	**474.5**
Total Carbon Dioxide Emissions by Primary Fuel[7]									
Petroleum[3]	649.7	701.1	693.4	688.7	683.1	752.6	748.4	716.1	717.2
Natural Gas	311.8	377.5	384.7	371.0	379.1	414.0	456.2	396.8	438.1
Coal	549.3	622.7	521.2	617.3	523.5	653.8	399.0	642.0	408.7
Other[5]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total[3]	**1510.8**	**1701.4**	**1599.3**	**1677.0**	**1585.6**	**1820.6**	**1603.6**	**1754.9**	**1564.1**
Carbon Dioxide Emissions (tons carbon equivalent per person)	**5.5**	**5.9**	**5.6**	**5.8**	**5.5**	**6.1**	**5.3**	**5.8**	**5.2**

[1]Includes consumption by cogenerators.
[2]Includes lease and plant fuel.
[3]This includes international bunker fuel which, by convention are excluded from the international accounting of carbon dioxide emissions. In the years from 1990 through 1998, international bunker fuels accounted for 25 to 30 million metric tons carbon equivalent of carbon dioxide annually.
[4]Includes pipeline fuel natural gas and compressed natural gas used as vehicle fuel.
[5]Includes methanol and liquid hydrogen.
[6]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators. Does not include emissions from the nonbiogenic component of municipal solid waste because under international guidelines these are accounted for as waste not energy.
[7]Emissions from electric power generators are distributed to the primary fuels.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 emissions and emission factors: Energy Information Administration (EIA), *Emissions of Greenhouse Gases in the United States 1999,* DOE/EIA-0573(99) (Washington, DC, October 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
23.8	24.1	21.5	21.7	23.3	23.7	20.4	20.8
83.2	82.5	78.3	77.4	87.5	86.5	81.6	80.6
1.3	1.3	1.1	1.1	1.3	1.2	1.0	1.0
255.6	167.1	244.3	168.0	270.7	169.8	253.9	171.5
363.9	**274.9**	**345.2**	**268.2**	**382.7**	**281.2**	**356.9**	**273.9**
12.2	12.5	12.0	12.0	12.0	12.5	11.8	11.9
62.7	63.4	63.7	63.8	64.4	67.2	65.9	67.5
1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
259.2	169.1	247.0	170.4	268.3	166.6	251.1	168.4
336.0	**246.8**	**324.6**	**248.1**	**346.6**	**248.3**	**330.8**	**249.7**
108.1	109.8	100.6	104.9	113.0	115.6	103.2	107.6
170.6	174.8	168.5	171.6	180.1	187.5	175.8	181.3
65.5	64.8	60.9	60.4	65.6	65.8	59.4	58.9
214.7	135.1	200.0	132.5	226.3	133.4	204.9	130.0
559.0	**484.5**	**530.0**	**469.3**	**585.0**	**502.3**	**543.2**	**477.8**
655.8	653.1	604.2	602.6	703.5	700.7	629.2	628.2
16.4	17.1	16.2	17.7	18.0	18.8	17.8	19.4
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7.0	4.9	5.1	3.7	7.9	5.3	5.6	4.0
679.2	**675.1**	**625.7**	**624.1**	**729.5**	**724.9**	**652.7**	**651.6**
799.8	799.5	738.2	741.3	851.8	852.4	764.5	768.4
333.0	337.8	326.8	330.4	350.0	360.1	341.2	348.8
68.7	68.0	63.9	63.4	68.8	69.0	62.3	61.8
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
736.5	476.1	696.5	474.7	773.1	475.2	715.5	474.0
1938.1	**1681.5**	**1825.5**	**1609.8**	**2043.8**	**1756.7**	**1883.6**	**1653.0**
5.1	2.3	3.7	2.0	4.8	2.2	3.3	1.8
133.8	176.9	110.6	152.7	163.6	203.5	133.6	174.0
597.6	297.0	582.2	319.9	604.7	269.5	578.6	298.2
736.5	**476.1**	**696.5**	**474.7**	**773.1**	**475.2**	**715.5**	**474.0**
804.9	801.8	741.9	743.3	856.5	854.6	767.8	770.2
466.8	514.7	437.4	483.1	513.6	563.6	474.8	522.8
666.3	364.9	646.1	383.3	673.5	338.4	640.9	360.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1938.1	**1681.5**	**1825.5**	**1609.8**	**2043.8**	**1756.7**	**1883.6**	**1653.0**
6.2	**5.4**	**5.8**	**5.1**	**6.3**	**5.4**	**5.8**	**5.1**

Table C20. Emissions, Allowance Costs, and Retrofits: Electric Generators, Excluding Cogenerators

Impacts	1999	Projections 2005 Reference	2005 Reference with Emissions Limits	2005 Advanced Technology	2005 Advanced Technology with Emissions Limits	2010 Reference	2010 Reference with Emissions Limits	2010 Advanced Technology	2010 Advanced Technology with Emissions Limits
Emissions									
Nitrogen Oxides (million tons)	5.43	4.30	2.70	4.26	2.67	4.34	1.64	4.18	1.76
Sulfur Dioxide (million tons)	13.49	10.39	6.34	10.39	6.34	9.70	2.99	9.70	2.99
Mercury (tons)	43.35	45.02	26.20	45.04	26.20	45.53	4.30	46.17	4.30
Carbon Dioxide (million metric tons carbon equivalent)	556.3	643.1	541.5	633.7	541.7	690.7	475.8	667.0	474.5
Allowance Prices									
Nitrogen Oxides (1999 dollars per ton)									
Summer Seasonal	0	4370	8	4270	24	4404	0	3327	0
National Annual	0	0	1003	0	1094	0	0	0	0
Sulfur Dioxide (1999 dollars per ton)	0	184	291	184	264	180	46	168	152
Mercury (million 1999 dollars per ton)	0	0	56	0	74	0	482	0	510
Carbon Dioxide (1999 dollars per ton carbon equivalent)	0	0	53	0	43	0	93	0	69
Retrofits (gigawatts, cumulative from 1999)									
Scrubber [1]	0.0	8.9	8.1	7.2	9.3	8.9	33.6	7.2	39.2
Combustion	0.0	40.4	42.7	40.4	41.7	42.5	50.9	42.8	49.6
SCR Post-combustion	0.0	90.8	68.9	90.9	68.5	90.9	101.8	91.0	98.2
SNCR Post-combustion	0.0	28.5	26.9	27.1	28.4	28.5	37.1	27.2	39.1
Mercury Spray Cooler	0.0	0.0	0.0	0.0	0.0	0.0	48.4	0.0	61.5
Mercury Fabric Filter	0.0	0.0	0.0	0.0	0.0	0.0	88.0	0.0	92.3
Coal Production by Sulfur Category (million tons)									
Low Sulfur (< .61 lbs. S/mmBtu)	473	582	541	584	546	633	408	620	416
Medium Sulfur (.61-1.67 lbs. S/mmBtu)	433	456	351	451	351	465	259	457	265
High Sulfur (> 1.67 lbs. S/mmBtu)	196	190	137	187	139	191	116	194	120

[1]Represents scrubbers added by the model. Planned scrubbers added by electricity generators are not shown here.
SCR = Selective catalytic reduction.
SNCR = Selective noncatalytic reduction.
lbs. S/mmBtu = Pounds sulfur per million British thermal units.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081601A, SCENBBS.D080301A, SCENBEM.D081701A.

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
4.44	1.53	4.26	1.68	4.48	1.42	4.25	1.58
8.95	2.64	8.95	2.64	8.95	2.24	8.95	2.24
44.98	4.30	45.79	4.30	45.23	4.30	45.10	4.30
736.5	476.1	696.5	474.7	773.1	475.2	715.5	474.0
4717	0	3663	0	5087	0	3886	0
0	0	0	0	0	0	0	0
252	18	213	253	200	221	145	703
0	406	0	410	0	306	0	374
0	111	0	76	0	122	0	58
14.2	37.0	7.2	40.5	17.5	37.0	9.8	40.5
44.4	52.0	44.0	51.0	46.6	52.4	45.4	51.7
91.1	101.8	91.0	98.2	91.1	101.9	91.0	98.2
36.0	37.1	27.2	39.1	46.0	37.1	27.2	39.1
0.0	49.2	0.0	63.5	0.0	49.2	0.0	63.5
0.0	88.3	0.0	95.7	0.0	88.3	0.0	95.7
692	371	653	395	714	360	651	371
440	234	445	243	442	214	435	241
186	117	184	119	180	105	184	105

Appendix D

Tables for the *CEF-JL* Moderate and Advanced Cases

Table D1. Total Energy Supply and Disposition Summary
(Quadrillion Btu per Year, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF -JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Production											
Crude Oil and Lease Condensate	12.45	12.04	12.00	12.03	12.03	12.03	11.23	11.18	11.15	11.07	11.14
Natural Gas Plant Liquids	2.62	3.11	2.98	3.07	2.92	3.02	3.36	3.14	3.48	3.15	3.32
Dry Natural Gas	19.16	21.88	20.98	21.64	20.54	21.28	23.97	22.37	24.87	22.46	23.69
Coal	23.06	25.43	25.10	21.95	23.18	21.36	26.49	26.04	17.67	21.16	17.84
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.90	7.69	7.69	7.91	7.85	7.85
Renewable Energy[1]	6.52	7.09	7.38	8.49	8.75	9.05	7.86	8.04	10.17	10.13	10.56
Other[2]	1.65	0.35	0.59	0.59	0.51	0.58	0.30	0.55	0.33	0.53	0.32
Total	**73.26**	**77.79**	**76.94**	**75.68**	**75.82**	**75.23**	**80.90**	**79.00**	**75.57**	**76.35**	**74.71**
Imports											
Crude Oil[3]	18.96	21.42	21.43	21.41	21.18	21.17	22.49	22.56	22.66	22.39	22.30
Petroleum Products[4]	4.14	6.11	5.60	5.28	3.90	3.72	8.52	7.63	7.15	4.57	4.49
Natural Gas	3.63	5.14	5.07	4.91	4.72	4.76	5.55	5.29	5.71	5.15	5.46
Other Imports[5]	0.64	1.11	1.09	1.01	1.04	1.04	0.96	0.94	0.87	0.81	0.81
Total	**27.37**	**33.78**	**33.20**	**32.61**	**30.84**	**30.69**	**37.52**	**36.42**	**36.39**	**32.91**	**33.06**
Exports											
Petroleum[6]	1.98	1.73	1.76	1.76	1.76	1.77	1.73	1.74	1.73	1.66	1.64
Natural Gas	0.17	0.33	0.33	0.33	0.33	0.33	0.43	0.43	0.43	0.43	0.43
Coal	1.48	1.51	1.51	1.52	1.51	1.52	1.45	1.45	1.52	1.45	1.52
Total	**3.62**	**3.56**	**3.59**	**3.61**	**3.59**	**3.62**	**3.61**	**3.62**	**3.68**	**3.54**	**3.59**
Discrepancy[7]	**0.67**	**0.44**	**0.56**	**0.57**	**0.46**	**0.52**	**0.06**	**0.25**	**0.10**	**0.22**	**0.11**
Consumption											
Petroleum Products[8]	37.92	41.21	40.64	40.40	38.63	38.57	44.30	43.24	43.12	40.00	40.00
Natural Gas	22.32	26.38	25.42	25.91	24.63	25.39	28.94	27.08	29.97	27.03	28.55
Coal	21.40	24.37	24.03	20.79	22.07	20.24	25.57	25.10	16.48	20.10	16.72
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.90	7.69	7.69	7.91	7.85	7.85
Renewable Energy[1]	6.53	7.10	7.38	8.49	8.75	9.06	7.87	8.04	10.17	10.14	10.56
Other[9]	0.35	0.61	0.61	0.63	0.61	0.61	0.38	0.39	0.53	0.39	0.39
Total	**96.33**	**107.56**	**105.99**	**104.12**	**102.60**	**101.78**	**114.74**	**111.54**	**108.18**	**105.50**	**104.08**
Net Imports - Petroleum	**21.12**	**25.80**	**25.28**	**24.93**	**23.32**	**23.12**	**29.28**	**28.45**	**28.08**	**25.29**	**25.15**
Prices (1999 dollars per unit)											
World Oil Price (dollars per barrel)[10]	17.22	20.83	20.83	20.83	20.83	20.83	21.37	21.37	21.37	21.37	21.37
Gas Wellhead Price (dollars per Mcf)[11]	2.08	2.99	2.80	2.83	2.52	2.72	2.82	2.45	2.91	2.28	2.76
Coal Minemouth Price (dollars per ton)	17.13	15.22	14.79	14.66	14.94	14.46	14.19	13.93	15.08	13.88	14.27
Average Electric Price (cents per Kwh)	6.7	6.4	6.2	6.8	6.8	6.9	6.1	5.8	7.1	6.5	6.7

[1]Includes grid-connected electricity from conventional hydroelectric; wood and wood waste; landfill gas; municipal solid waste; other biomass; wind; photovoltaic and solar thermal sources; non-electric energy from renewable sources, such as active and passive solar systems, and wood; and both the ethanol and gasoline components of E85, but not the ethanol components of blends less than 85 percent. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table D18 for selected nonmarketed residential and commercial renewable energy.
[2]Includes liquid hydrogen, methanol, supplemental natural gas, and some domestic inputs to refineries.
[3]Includes imports of crude oil for the Strategic Petroleum Reserve.
[4]Includes imports of finished petroleum products, imports of unfinished oils, alcohols, ethers, and blending components.
[5]Includes coal, coal coke (net), and electricity (net).
[6]Includes crude oil and petroleum products.
[7]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[8]Includes natural gas plant liquids, crude oil consumed as a fuel, and nonpetroleum based liquids for blending, such as ethanol.
[9]Includes net electricity imports, methanol, and liquid hydrogen.
[10]Average refiner acquisition cost for imported crude oil.
[11]Represents lower 48 onshore and offshore supplies.
Btu = British thermal unit.
Mcf = Thousand cubic feet.
Kwh = Kilowatthour.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 natural gas values: Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). 1999 petroleum values: EIA, *Petroleum Supply Annual 1999,* DOE/EIA-0340(99/1) (Washington, DC, June 2000). Other 1999 values: EIA, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000) and EIA, *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
11.08	10.89	11.06	10.75	10.96	11.06	10.74	10.95	10.71	10.81
3.76	3.37	3.68	3.31	3.48	4.14	3.60	3.87	3.53	3.67
27.19	24.30	26.56	23.77	25.12	30.10	26.11	28.14	25.53	26.64
26.84	26.27	17.12	20.37	17.17	27.10	26.52	16.80	19.25	16.42
6.98	6.98	7.54	7.09	7.21	6.51	6.35	6.89	6.14	6.59
8.16	8.31	10.48	10.52	10.88	8.37	8.59	11.49	10.83	11.11
0.31	0.60	0.50	0.55	0.46	0.33	0.93	0.87	0.91	0.68
84.31	**80.73**	**76.94**	**76.35**	**75.27**	**87.61**	**82.84**	**79.02**	**76.89**	**75.90**
25.27	24.81	24.61	23.26	23.04	25.91	26.30	25.90	24.12	24.12
8.67	7.75	7.39	4.85	4.75	10.70	8.06	7.98	4.88	4.80
6.11	5.64	6.16	5.52	5.80	6.55	5.97	6.40	5.89	6.09
0.88	0.87	0.75	0.73	0.73	0.96	0.94	0.80	0.80	0.80
40.93	**39.06**	**38.91**	**34.36**	**34.33**	**44.11**	**41.27**	**41.08**	**35.68**	**35.81**
1.73	1.70	1.71	1.68	1.70	1.82	1.79	1.82	1.81	1.83
0.53	0.53	0.53	0.53	0.53	0.63	0.63	0.63	0.63	0.63
1.40	1.35	1.52	1.39	1.52	1.41	1.41	1.51	1.45	1.47
3.67	**3.58**	**3.76**	**3.60**	**3.76**	**3.87**	**3.83**	**3.96**	**3.90**	**3.94**
0.23	**0.22**	**0.08**	**0.06**	**0.03**	**0.18**	**0.06**	**-0.03**	**-0.01**	**-0.09**
47.33	45.66	45.59	41.10	41.11	50.36	47.93	47.88	42.44	42.46
32.60	29.27	32.02	28.62	30.23	35.88	31.32	33.75	30.66	31.96
26.03	25.52	15.98	19.46	16.13	26.30	25.76	15.74	18.33	15.46
6.98	6.98	7.54	7.09	7.21	6.51	6.35	6.89	6.14	6.59
8.17	8.32	10.49	10.53	10.88	8.38	8.60	11.50	10.84	11.12
0.24	0.25	0.38	0.26	0.26	0.25	0.27	0.39	0.27	0.27
121.34	**115.99**	**112.01**	**107.05**	**105.82**	**127.68**	**120.22**	**116.16**	**108.68**	**107.86**
32.21	**30.86**	**30.30**	**26.43**	**26.09**	**34.78**	**32.56**	**32.06**	**27.18**	**27.08**
21.89	21.89	21.89	21.89	21.89	22.41	22.41	22.41	22.41	22.41
2.92	2.48	2.91	2.37	2.71	3.10	2.48	2.82	2.36	2.61
13.40	13.24	14.44	12.71	13.79	12.93	12.78	13.47	11.51	13.45
6.1	5.9	7.3	6.5	6.6	6.1	6.0	7.2	6.6	6.6

Table D2. Energy Consumption by Sector and Source
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Energy Consumption											
Residential											
Distillate Fuel	0.86	0.87	0.87	0.87	0.84	0.84	0.80	0.79	0.80	0.76	0.76
Kerosene	0.10	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07
Liquefied Petroleum Gas	0.46	0.46	0.45	0.45	0.44	0.44	0.43	0.42	0.42	0.41	0.41
Petroleum Subtotal	1.42	1.41	1.40	1.40	1.36	1.36	1.30	1.29	1.29	1.23	1.24
Natural Gas	4.88	5.55	5.53	5.49	5.40	5.36	5.54	5.54	5.42	5.36	5.26
Coal	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Renewable Energy[1]	0.41	0.42	0.42	0.42	0.41	0.41	0.42	0.42	0.42	0.41	0.41
Electricity	3.91	4.56	4.48	4.37	4.34	4.31	4.91	4.64	4.40	4.39	4.34
Delivered Energy	**10.66**	**11.99**	**11.88**	**11.73**	**11.55**	**11.49**	**12.22**	**11.93**	**11.58**	**11.44**	**11.30**
Electricity Related Losses	8.44	9.66	9.54	8.91	9.10	8.85	10.00	9.62	8.57	8.79	8.39
Total	**19.10**	**21.65**	**21.42**	**20.64**	**20.65**	**20.35**	**22.22**	**21.55**	**20.15**	**20.23**	**19.69**
Commercial											
Distillate Fuel	0.36	0.37	0.38	0.38	0.35	0.35	0.38	0.38	0.39	0.34	0.34
Residual Fuel	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Kerosene	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Liquefied Petroleum Gas	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Motor Gasoline[2]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Petroleum Subtotal	0.60	0.61	0.61	0.61	0.58	0.58	0.62	0.62	0.63	0.58	0.58
Natural Gas	3.14	3.99	3.94	3.93	3.92	3.88	4.19	4.12	4.05	4.12	4.04
Coal	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Renewable Energy[3]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Electricity	3.66	4.40	4.22	4.13	4.17	4.14	4.92	4.56	4.40	4.51	4.47
Delivered Energy	**7.55**	**9.15**	**8.92**	**8.83**	**8.82**	**8.76**	**9.88**	**9.46**	**9.24**	**9.36**	**9.24**
Electricity Related Losses	7.91	9.33	8.97	8.44	8.75	8.51	10.02	9.46	8.57	9.04	8.63
Total	**15.46**	**18.48**	**17.89**	**17.27**	**17.56**	**17.27**	**19.90**	**18.91**	**17.81**	**18.40**	**17.87**
Industrial[4]											
Distillate Fuel	1.13	1.21	1.20	1.19	1.18	1.18	1.30	1.27	1.26	1.24	1.24
Liquefied Petroleum Gas	2.32	2.44	2.38	2.39	2.33	2.35	2.51	2.39	2.40	2.35	2.36
Petrochemical Feedstock	1.29	1.36	1.33	1.33	1.31	1.31	1.53	1.46	1.46	1.43	1.43
Residual Fuel	0.22	0.16	0.16	0.16	0.15	0.15	0.25	0.24	0.25	0.20	0.22
Motor Gasoline[2]	0.21	0.23	0.22	0.22	0.22	0.22	0.25	0.24	0.24	0.24	0.24
Other Petroleum[5]	4.29	4.41	4.39	4.39	4.33	4.33	4.68	4.57	4.62	4.48	4.50
Petroleum Subtotal	9.45	9.81	9.69	9.69	9.52	9.54	10.51	10.18	10.23	9.94	9.99
Natural Gas[6]	9.80	10.42	10.29	10.32	10.21	10.19	11.27	10.99	11.20	10.74	10.69
Metallurgical Coal	0.75	0.67	0.67	0.67	0.63	0.63	0.61	0.61	0.61	0.52	0.52
Steam Coal	1.73	1.80	1.79	1.80	1.71	1.72	1.82	1.79	1.74	1.64	1.60
Net Coal Coke Imports	0.06	0.11	0.09	0.09	0.13	0.13	0.15	0.13	0.13	0.21	0.21
Coal Subtotal	2.54	2.59	2.56	2.56	2.48	2.48	2.58	2.53	2.49	2.37	2.33
Renewable Energy[7]	2.15	2.40	2.39	2.39	2.43	2.43	2.63	2.60	2.60	2.75	2.75
Electricity	3.61	3.88	3.83	3.78	3.75	3.74	4.16	4.08	3.88	3.89	3.87
Delivered Energy	**27.56**	**29.10**	**28.75**	**28.74**	**28.40**	**28.39**	**31.14**	**30.38**	**30.41**	**29.68**	**29.63**
Electricity Related Losses	7.80	8.21	8.16	7.73	7.87	7.68	8.47	8.46	7.56	7.79	7.48
Total	**35.36**	**37.31**	**36.91**	**36.47**	**36.27**	**36.06**	**39.61**	**38.83**	**37.97**	**37.46**	**37.10**

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
0.78	0.77	0.77	0.72	0.72	0.76	0.75	0.75	0.70	0.70
0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
0.41	0.40	0.41	0.38	0.38	0.41	0.39	0.40	0.37	0.37
1.26	1.23	1.25	1.17	1.17	1.23	1.20	1.22	1.13	1.14
5.78	5.79	5.65	5.53	5.44	6.08	6.11	5.97	5.77	5.68
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
0.43	0.43	0.42	0.42	0.41	0.43	0.44	0.42	0.43	0.42
5.27	4.68	4.41	4.24	4.21	5.69	4.79	4.53	4.19	4.18
12.79	**12.19**	**11.78**	**11.41**	**11.28**	**13.48**	**12.59**	**12.19**	**11.57**	**11.46**
10.28	9.44	8.32	8.16	7.81	10.65	9.42	8.35	7.61	7.39
23.08	**21.63**	**20.10**	**19.57**	**19.10**	**24.14**	**22.01**	**20.54**	**19.18**	**18.85**
0.38	0.38	0.40	0.32	0.32	0.37	0.37	0.39	0.30	0.30
0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.62	0.63	0.64	0.56	0.57	0.62	0.62	0.64	0.55	0.55
4.36	4.25	4.21	4.20	4.13	4.47	4.36	4.40	4.31	4.25
0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.07	0.07
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
5.35	4.77	4.57	4.66	4.64	5.64	4.85	4.62	4.68	4.66
10.48	**9.80**	**9.57**	**9.58**	**9.49**	**10.88**	**9.98**	**9.83**	**9.68**	**9.61**
10.43	9.63	8.61	8.97	8.60	10.56	9.53	8.53	8.50	8.25
20.91	**19.43**	**18.19**	**18.54**	**18.09**	**21.44**	**19.51**	**18.35**	**18.18**	**17.86**
1.39	1.35	1.34	1.30	1.30	1.49	1.43	1.42	1.37	1.37
2.67	2.48	2.51	2.41	2.45	2.85	2.59	2.65	2.51	2.52
1.61	1.51	1.51	1.46	1.46	1.69	1.57	1.57	1.52	1.52
0.26	0.25	0.26	0.22	0.22	0.27	0.25	0.26	0.19	0.20
0.26	0.26	0.26	0.25	0.25	0.28	0.28	0.27	0.27	0.27
4.81	4.66	4.71	4.55	4.56	5.00	4.77	4.81	4.61	4.64
11.01	10.51	10.59	10.20	10.24	11.58	10.89	10.99	10.47	10.51
12.03	11.57	11.91	11.11	11.06	12.71	12.18	12.66	11.64	11.60
0.55	0.56	0.56	0.43	0.43	0.50	0.51	0.51	0.36	0.36
1.84	1.80	1.77	1.62	1.59	1.86	1.81	1.78	1.59	1.57
0.19	0.17	0.17	0.28	0.28	0.22	0.21	0.21	0.33	0.33
2.58	2.53	2.50	2.33	2.29	2.59	2.52	2.49	2.28	2.26
2.85	2.81	2.81	3.08	3.08	3.07	3.03	3.02	3.43	3.43
4.43	4.30	3.94	4.03	4.02	4.76	4.54	4.04	4.18	4.19
32.90	**31.71**	**31.75**	**30.74**	**30.70**	**34.72**	**33.16**	**33.20**	**32.00**	**31.99**
8.64	8.67	7.44	7.74	7.46	8.91	8.92	7.46	7.59	7.41
41.54	**40.38**	**39.19**	**38.48**	**38.16**	**43.63**	**42.08**	**40.66**	**39.59**	**39.40**

Table D2. Energy Consumption by Sector and Source (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	1999	Projections: 2005 Reference	2005 CEF-JL Moderate	2005 CEF-JL Moderate with Emissions Limits	2005 CEF-JL Advanced	2005 CEF-JL Advanced with Emissions Limits	2010 Reference	2010 CEF-JL Moderate	2010 CEF-JL Moderate with Emissions Limits	2010 CEF-JL Advanced	2010 CEF-JL Advanced with Emissions Limits
Transportation											
Distillate Fuel	5.13	6.25	6.07	6.03	5.94	5.93	6.98	6.69	6.61	6.42	6.39
Jet Fuel[8]	3.46	3.88	3.90	3.89	3.87	3.86	4.49	4.52	4.52	4.42	4.41
Motor Gasoline[2]	15.92	17.64	17.49	17.49	16.03	16.02	18.94	18.54	18.53	16.10	16.10
Residual Fuel	0.74	0.85	0.85	0.85	0.84	0.84	0.85	0.85	0.85	0.85	0.85
Liquefied Petroleum Gas	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Other Petroleum[9]	0.26	0.29	0.29	0.29	0.29	0.29	0.31	0.31	0.31	0.31	0.31
Petroleum Subtotal	25.54	28.95	28.63	28.58	27.01	26.97	31.62	30.95	30.86	28.14	28.10
Pipeline Fuel Natural Gas	0.66	0.82	0.79	0.81	0.77	0.80	0.90	0.85	0.95	0.85	0.91
Compressed Natural Gas	0.02	0.05	0.05	0.05	0.05	0.05	0.09	0.09	0.09	0.08	0.08
Renewable Energy (E85)[10]	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Methanol (M85)[11]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Electricity	0.06	0.09	0.09	0.09	0.08	0.08	0.12	0.10	0.10	0.10	0.10
Delivered Energy	**26.28**	**29.94**	**29.58**	**29.56**	**27.94**	**27.94**	**32.77**	**32.04**	**32.05**	**29.21**	**29.23**
Electricity Related Losses	0.13	0.19	0.18	0.17	0.18	0.17	0.24	0.21	0.20	0.20	0.19
Total	**26.41**	**30.12**	**29.77**	**29.74**	**28.11**	**28.11**	**33.01**	**32.25**	**32.25**	**29.41**	**29.42**
Delivered Energy Consumption for All Sectors											
Distillate Fuel	7.48	8.70	8.51	8.47	8.31	8.30	9.46	9.13	9.06	8.76	8.74
Kerosene	0.15	0.13	0.13	0.13	0.13	0.13	0.12	0.13	0.13	0.12	0.12
Jet Fuel[8]	3.46	3.88	3.90	3.89	3.87	3.86	4.49	4.52	4.52	4.42	4.41
Liquefied Petroleum Gas	2.88	3.02	2.96	2.96	2.89	2.91	3.07	2.94	2.95	2.89	2.90
Motor Gasoline[2]	16.17	17.90	17.74	17.74	16.28	16.27	19.22	18.81	18.80	16.37	16.36
Petrochemical Feedstock	1.29	1.36	1.33	1.33	1.31	1.31	1.53	1.46	1.46	1.43	1.43
Residual Fuel	1.05	1.10	1.10	1.10	1.09	1.09	1.20	1.18	1.19	1.14	1.16
Other Petroleum[12]	4.53	4.68	4.66	4.66	4.60	4.60	4.96	4.86	4.90	4.77	4.78
Petroleum Subtotal	37.01	40.77	40.33	40.29	38.47	38.46	44.05	43.03	43.02	39.89	39.91
Natural Gas[6]	18.50	20.84	20.60	20.61	20.35	20.28	21.99	21.59	21.70	21.15	20.97
Metallurgical Coal	0.75	0.67	0.67	0.67	0.63	0.63	0.61	0.61	0.61	0.52	0.52
Steam Coal	1.84	1.92	1.91	1.91	1.83	1.83	1.94	1.91	1.87	1.76	1.72
Net Coal Coke Imports	0.06	0.11	0.09	0.09	0.13	0.13	0.15	0.13	0.13	0.21	0.21
Coal Subtotal	2.65	2.70	2.67	2.68	2.59	2.60	2.70	2.66	2.62	2.49	2.45
Renewable Energy[13]	2.65	2.93	2.91	2.91	2.95	2.95	3.17	3.14	3.14	3.27	3.27
Methanol (M85)[11]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Electricity	11.24	12.93	12.62	12.37	12.34	12.28	14.10	13.37	12.78	12.89	12.78
Delivered Energy	**72.05**	**80.17**	**79.14**	**78.86**	**76.71**	**76.57**	**86.01**	**83.80**	**83.27**	**79.70**	**79.40**
Electricity Related Losses	24.28	27.39	26.85	25.25	25.89	25.21	28.73	27.74	24.90	25.81	24.68
Total	**96.33**	**107.56**	**105.99**	**104.12**	**102.60**	**101.78**	**114.74**	**111.54**	**108.18**	**105.50**	**104.08**
Electric Generators[14]											
Distillate Fuel	0.05	0.06	0.05	0.02	0.02	0.02	0.06	0.05	0.02	0.02	0.01
Residual Fuel	0.86	0.37	0.26	0.10	0.14	0.09	0.20	0.16	0.08	0.09	0.08
Petroleum Subtotal	0.91	0.43	0.32	0.11	0.16	0.11	0.25	0.21	0.10	0.11	0.10
Natural Gas	3.83	5.54	4.81	5.30	4.29	5.11	6.96	5.49	8.26	5.89	7.58
Steam Coal	18.75	21.67	21.36	18.11	19.48	17.65	22.87	22.44	13.86	17.61	14.27
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.90	7.69	7.69	7.91	7.85	7.85
Renewable Energy[15]	3.88	4.17	4.47	5.58	5.80	6.11	4.70	4.90	7.04	6.86	7.30
Electricity Imports[16]	0.35	0.61	0.61	0.62	0.61	0.61	0.37	0.37	0.51	0.37	0.37
Total	**35.52**	**40.32**	**39.47**	**37.62**	**38.24**	**37.49**	**42.83**	**41.11**	**37.69**	**38.69**	**37.46**

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
7.61	7.16	7.08	6.75	6.73	8.21	7.58	7.50	7.05	7.03
5.22	5.22	5.23	4.99	4.99	5.96	5.90	5.91	5.65	5.65
20.14	19.46	19.46	16.08	16.08	21.25	20.26	20.25	16.22	16.23
0.86	0.86	0.86	0.86	0.86	0.86	0.87	0.87	0.87	0.87
0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06
0.33	0.33	0.33	0.33	0.33	0.35	0.35	0.35	0.35	0.35
34.20	33.08	33.01	29.06	29.04	36.70	35.01	34.94	30.20	30.18
1.01	0.91	0.99	0.88	0.94	1.10	0.96	1.03	0.94	0.98
0.13	0.12	0.12	0.11	0.11	0.16	0.15	0.15	0.13	0.13
0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.05	0.05
0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
0.00	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.02
0.15	0.12	0.12	0.12	0.12	0.17	0.14	0.14	0.14	0.14
35.53	**34.30**	**34.31**	**30.24**	**30.26**	**38.16**	**36.34**	**36.34**	**31.48**	**31.50**
0.28	0.25	0.23	0.22	0.22	0.31	0.28	0.26	0.25	0.24
35.81	**34.55**	**34.53**	**30.46**	**30.48**	**38.47**	**36.62**	**36.60**	**31.73**	**31.74**
10.15	9.66	9.59	9.10	9.08	10.82	10.13	10.07	9.42	9.40
0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
5.22	5.22	5.23	4.99	4.99	5.96	5.90	5.91	5.65	5.65
3.23	3.02	3.06	2.93	2.98	3.41	3.12	3.20	3.03	3.04
20.43	19.74	19.74	16.36	16.36	21.56	20.56	20.55	16.52	16.52
1.61	1.51	1.51	1.46	1.46	1.69	1.57	1.57	1.52	1.52
1.21	1.20	1.21	1.17	1.17	1.23	1.22	1.22	1.15	1.16
5.12	4.96	5.02	4.86	4.86	5.33	5.10	5.14	4.94	4.97
47.09	45.44	45.49	40.99	41.02	50.13	47.72	47.78	42.35	42.38
23.30	22.64	22.88	21.83	21.67	24.52	23.75	24.21	22.79	22.64
0.55	0.56	0.56	0.43	0.43	0.50	0.51	0.51	0.36	0.36
1.97	1.92	1.90	1.74	1.71	1.99	1.93	1.90	1.71	1.69
0.19	0.17	0.17	0.28	0.28	0.22	0.21	0.21	0.33	0.33
2.71	2.65	2.63	2.45	2.41	2.71	2.65	2.62	2.40	2.38
3.40	3.37	3.36	3.62	3.61	3.64	3.61	3.59	4.00	3.98
0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
0.00	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.02
15.19	13.87	13.05	13.05	12.99	16.25	14.32	13.34	13.18	13.15
91.70	**88.00**	**87.41**	**81.96**	**81.73**	**97.25**	**92.07**	**91.56**	**84.74**	**84.56**
29.64	27.99	24.59	25.09	24.09	30.43	28.15	24.60	23.95	23.29
121.34	**115.99**	**112.01**	**107.05**	**105.82**	**127.68**	**120.22**	**116.16**	**108.68**	**107.86**
0.06	0.05	0.02	0.02	0.01	0.06	0.06	0.02	0.02	0.01
0.18	0.16	0.08	0.08	0.07	0.17	0.15	0.08	0.08	0.07
0.24	0.21	0.10	0.10	0.09	0.23	0.21	0.10	0.09	0.08
9.29	6.62	9.15	6.79	8.55	11.36	7.56	9.54	7.88	9.32
23.33	22.87	13.36	17.01	13.72	23.59	23.11	13.12	15.93	13.08
6.98	6.98	7.54	7.09	7.21	6.51	6.35	6.89	6.14	6.59
4.76	4.95	7.13	6.91	7.27	4.75	4.99	7.91	6.84	7.13
0.23	0.23	0.36	0.23	0.23	0.24	0.24	0.37	0.24	0.24
44.83	**41.86**	**37.64**	**38.14**	**37.07**	**46.68**	**42.47**	**37.94**	**37.12**	**36.45**

Table D2. Energy Consumption by Sector and Source (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	1999	Projections 2005 Reference	2005 CEF-JL Moderate	2005 CEF-JL Moderate with Emissions Limits	2005 CEF-JL Advanced	2005 CEF-JL Advanced with Emissions Limits	2010 Reference	2010 CEF-JL Moderate	2010 CEF-JL Moderate with Emissions Limits	2010 CEF-JL Advanced	2010 CEF-JL Advanced with Emissions Limits
Total Energy Consumption											
Distillate Fuel	7.53	8.77	8.57	8.49	8.34	8.32	9.51	9.18	9.08	8.78	8.75
Kerosene	0.15	0.13	0.13	0.13	0.13	0.13	0.12	0.13	0.13	0.12	0.12
Jet Fuel[8]	3.46	3.88	3.90	3.89	3.87	3.86	4.49	4.52	4.52	4.42	4.41
Liquefied Petroleum Gas	2.88	3.02	2.96	2.96	2.89	2.91	3.07	2.94	2.95	2.89	2.90
Motor Gasoline[2]	16.17	17.90	17.74	17.74	16.28	16.27	19.22	18.81	18.80	16.37	16.36
Petrochemical Feedstock	1.29	1.36	1.33	1.33	1.31	1.31	1.53	1.46	1.46	1.43	1.43
Residual Fuel	1.92	1.48	1.36	1.19	1.23	1.18	1.39	1.34	1.28	1.24	1.24
Other Petroleum[12]	4.53	4.68	4.66	4.66	4.60	4.60	4.96	4.86	4.90	4.77	4.78
Petroleum Subtotal	37.92	41.21	40.64	40.40	38.63	38.57	44.30	43.24	43.12	40.00	40.00
Natural Gas	22.32	26.38	25.42	25.91	24.63	25.39	28.94	27.08	29.97	27.03	28.55
Metallurgical Coal	0.75	0.67	0.67	0.67	0.63	0.63	0.61	0.61	0.61	0.52	0.52
Steam Coal	20.59	23.59	23.26	20.02	21.30	19.48	24.81	24.35	15.73	19.37	15.99
Net Coal Coke Imports	0.06	0.11	0.09	0.09	0.13	0.13	0.15	0.13	0.13	0.21	0.21
Coal Subtotal	21.40	24.37	24.03	20.79	22.07	20.24	25.57	25.10	16.48	20.10	16.72
Nuclear Power	7.79	7.90	7.90	7.90	7.90	7.90	7.69	7.69	7.91	7.85	7.85
Renewable Energy[17]	6.53	7.10	7.38	8.49	8.75	9.06	7.87	8.04	10.18	10.14	10.56
Methanol (M85)[11]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Liquid Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Electricity Imports[16]	0.35	0.61	0.61	0.62	0.61	0.61	0.37	0.37	0.51	0.37	0.37
Total	**96.33**	**107.56**	**105.99**	**104.12**	**102.60**	**101.78**	**114.74**	**111.54**	**108.18**	**105.50**	**104.08**
Energy Use and Related Statistics											
Delivered Energy Use	72.05	80.17	79.14	78.86	76.71	76.57	86.01	83.80	83.27	79.70	79.40
Total Energy Use	96.33	107.56	105.99	104.12	102.60	101.78	114.74	111.54	108.18	105.50	104.08
Population (millions)	273.13	288.02	288.02	288.02	288.02	288.02	300.17	300.17	300.17	300.17	300.17
Gross Domestic Product (billion 1996 dollars)	8876	10960	10960	10925	10960	10952	12667	12667	12641	12667	12659
Carbon Dioxide Emissions (million metric tons carbon equivalent)	1510.8	1701.4	1669.5	1588.2	1570.2	1533.3	1820.6	1764.6	1581.2	1575.3	1509.9

[1]Includes wood used for residential heating. See Table D18 estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal hot water heating, and solar photovoltaic electricity generation.
[2]Includes ethanol (blends of 10 percent or less) and ethers blended into gasoline.
[3]Includes commercial sector electricity cogenerated by using wood and wood waste, landfill gas, municipal solid waste, and other biomass. See Table D18 for estimates of nonmarketed renewable energy consumption for solar thermal hot water heating and solar photovoltaic electricity generation.
[4]Fuel consumption includes consumption for cogeneration, which produces electricity and other useful thermal energy.
[5]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[6]Includes lease and plant fuel and consumption by cogenerators; excludes consumption by nonutility generators.
[7]Includes consumption of energy from hydroelectric, wood and wood waste, municipal solid waste, and other biomass; includes cogeneration, both for sale to the grid and for own use.
[8]Includes only kerosene type.
[9]Includes aviation gas and lubricants.
[10]E85 is 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable).
[11]M85 is 85 percent methanol and 15 percent motor gasoline.
[12]Includes unfinished oils, natural gasoline, motor gasoline blending compounds, aviation gasoline, lubricants, still gas, asphalt, road oil, petroleum coke, and miscellaneous petroleum products.
[13]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal hot water heaters.
[14]Includes consumption of energy by all electric power generators for grid-connected power except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[15]Includes conventional hydroelectric, geothermal, wood and wood waste, municipal solid waste, other biomass, petroleum coke, wind, photovoltaic and solar thermal sources. Excludes cogeneration. Excludes net electricity imports.
[16]In 1998 approximately 70 percent of the U.S. electricity imports were provided by renewable sources (hydroelectricity); EIA does not project future proportions for the fuel source of imported electricity.
[17]Includes hydroelectric, geothermal, wood and wood waste, municipal solid waste, other biomass, wind, photovoltaic and solar thermal sources. Includes ethanol components of E85; excludes ethanol blends (10 percent or less) in motor gasoline. Excludes net electricity imports and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal hot water heaters.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports. Consumption values of 0.00 are values that round to 0.00, because they are less than 0.005.
Sources: 1999 electric utility fuel consumption: Energy Information Administration (EIA), *Electric Power Annual 1998, Volume 1,* DOE/EIA-0348(98)/1 (Washington, DC, April 1999). 1999 nonutility consumption estimates: EIA, Form EIA-860B: "Annual Electric Generator Report - Nonutility." Other 1999 values: EIA, *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
10.21	9.71	9.61	9.11	9.09	10.88	10.19	10.09	9.44	9.42
0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
5.22	5.22	5.23	4.99	4.99	5.96	5.90	5.91	5.65	5.65
3.23	3.02	3.06	2.93	2.98	3.41	3.12	3.20	3.03	3.04
20.43	19.74	19.74	16.36	16.36	21.56	20.56	20.55	16.52	16.52
1.61	1.51	1.51	1.46	1.46	1.69	1.57	1.57	1.52	1.52
1.40	1.36	1.29	1.25	1.24	1.41	1.37	1.31	1.23	1.23
5.12	4.96	5.02	4.86	4.86	5.33	5.10	5.14	4.94	4.97
47.33	45.66	45.59	41.10	41.11	50.36	47.93	47.88	42.44	42.46
32.60	29.27	32.02	28.62	30.23	35.88	31.32	33.75	30.66	31.96
0.55	0.56	0.56	0.43	0.43	0.50	0.51	0.51	0.36	0.36
25.29	24.79	15.25	18.75	15.43	25.58	25.04	15.02	17.64	14.77
0.19	0.17	0.17	0.28	0.28	0.22	0.21	0.21	0.33	0.33
26.03	25.52	15.98	19.46	16.13	26.30	25.76	15.74	18.33	15.46
6.98	6.98	7.54	7.09	7.21	6.51	6.35	6.89	6.14	6.59
8.17	8.32	10.49	10.53	10.89	8.38	8.60	11.50	10.84	11.12
0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
0.00	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.02
0.23	0.23	0.36	0.23	0.23	0.24	0.24	0.37	0.24	0.24
121.34	**115.99**	**112.01**	**107.05**	**105.82**	**127.68**	**120.22**	**116.16**	**108.68**	**107.86**
91.70	88.00	87.41	81.96	81.73	97.25	92.07	91.56	84.74	84.56
121.34	115.99	112.01	107.05	105.82	127.68	120.22	116.16	108.68	107.86
312.58	312.58	312.58	312.58	312.58	325.24	325.24	325.24	325.24	325.24
14635	14635	14631	14635	14641	16515	16515	16513	16515	16514
1938.1	1846.1	1638.2	1596.8	1533.4	2043.8	1914.0	1689.5	1615.2	1558.4

Table D3. Energy Prices by Sector and Source
(1999 Dollars per Million Btu, Unless Otherwise Noted)

Sector and Source	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Residential	**13.18**	**13.33**	**13.00**	**13.61**	**13.42**	**13.70**	**13.41**	**12.80**	**14.17**	**13.32**	**13.85**
Primary Energy[1]	6.71	7.50	7.38	7.40	7.16	7.31	7.17	6.91	7.24	6.72	7.10
Petroleum Products[2]	7.55	9.17	9.14	9.08	9.02	9.00	9.37	9.36	9.27	8.95	9.10
Distillate Fuel	6.27	7.37	7.34	7.28	7.17	7.17	7.57	7.56	7.49	7.31	7.33
Liquefied Petroleum Gas	10.36	12.61	12.61	12.58	12.59	12.52	12.82	12.83	12.69	12.04	12.47
Natural Gas	6.52	7.13	6.98	7.03	6.75	6.94	6.70	6.39	6.81	6.26	6.69
Electricity	23.69	22.29	21.77	23.49	23.23	23.71	22.19	21.52	24.81	23.31	24.02
Commercial	**13.28**	**12.71**	**12.19**	**13.19**	**13.09**	**13.43**	**12.23**	**11.33**	**13.38**	**12.26**	**12.94**
Primary Energy[1]	5.22	5.58	5.44	5.47	5.21	5.37	5.65	5.38	5.72	5.21	5.59
Petroleum Products[2]	4.99	6.08	6.04	6.00	5.94	5.92	6.27	6.25	6.17	5.98	6.05
Distillate Fuel	4.37	5.17	5.13	5.08	4.96	4.96	5.35	5.34	5.26	5.09	5.10
Residual Fuel	2.63	3.64	3.62	3.59	3.60	3.60	3.70	3.68	3.67	3.67	3.67
Natural Gas[3]	5.34	5.57	5.41	5.45	5.16	5.35	5.63	5.32	5.73	5.17	5.59
Electricity	21.64	20.28	19.59	21.81	21.71	22.25	18.76	17.60	21.65	19.70	20.65
Industrial[4]	**5.29**	**5.75**	**5.60**	**5.86**	**5.74**	**5.86**	**5.62**	**5.33**	**5.99**	**5.44**	**5.79**
Primary Energy	3.91	4.46	4.37	4.37	4.21	4.30	4.45	4.26	4.40	4.03	4.30
Petroleum Products[2]	5.54	5.97	5.93	5.90	5.82	5.82	6.07	6.01	5.92	5.60	5.75
Distillate Fuel	4.65	5.33	5.30	5.25	5.14	5.14	5.53	5.52	5.45	5.28	5.30
Liquefied Petroleum Gas	8.50	7.75	7.73	7.72	7.68	7.64	7.77	7.75	7.62	6.94	7.43
Residual Fuel	2.78	3.37	3.36	3.34	3.35	3.34	3.43	3.42	3.42	3.42	3.42
Natural Gas[5]	2.79	3.66	3.50	3.54	3.24	3.44	3.46	3.12	3.56	2.96	3.42
Metallurgical Coal	1.66	1.58	1.58	1.59	1.59	1.58	1.54	1.54	1.55	1.53	1.53
Steam Coal	1.43	1.35	1.34	1.31	1.34	1.30	1.30	1.29	1.20	1.27	1.19
Electricity	13.12	12.81	12.38	14.17	14.16	14.53	12.04	11.15	15.09	13.18	14.01
Transportation	**8.30**	**9.33**	**9.29**	**9.29**	**8.79**	**8.79**	**9.63**	**9.61**	**9.63**	**8.80**	**8.81**
Primary Energy	8.29	9.32	9.28	9.27	8.77	8.77	9.61	9.60	9.61	8.78	8.79
Petroleum Products[2]	8.28	9.32	9.27	9.27	8.76	8.76	9.61	9.60	9.60	8.77	8.78
Distillate Fuel[6]	8.22	8.89	8.88	8.84	8.69	8.69	8.94	9.01	8.98	8.76	8.78
Jet Fuel[7]	4.70	5.22	5.21	5.18	5.05	5.05	5.49	5.49	5.48	5.19	5.22
Motor Gasoline[8]	9.45	10.75	10.70	10.71	10.07	10.07	11.20	11.19	11.21	10.14	10.14
Residual Fuel	2.46	3.11	3.14	3.13	3.13	3.13	3.18	3.25	3.25	3.26	3.26
Liquefied Petroleum Gas[9]	12.87	14.07	14.05	14.02	13.99	13.94	14.00	14.02	13.89	13.28	13.64
Natural Gas[10]	7.02	7.30	7.11	7.15	6.80	6.99	7.17	6.84	7.27	6.60	7.04
Ethanol (E85)[11]	14.42	19.20	19.16	19.17	18.96	18.99	19.13	19.07	19.11	18.75	18.79
Methanol (M85)[12]	10.38	13.13	12.97	13.00	12.90	12.76	13.80	13.79	13.80	13.53	13.59
Electricity	15.64	14.61	14.27	15.75	15.43	15.95	13.73	13.31	16.64	15.23	16.01
Average End-Use Energy	**8.52**	**9.16**	**8.97**	**9.26**	**8.99**	**9.11**	**9.16**	**8.85**	**9.50**	**8.76**	**9.04**
Primary Energy	6.31	7.16	7.09	7.09	6.71	6.77	7.30	7.18	7.29	6.61	6.79
Electricity	19.58	18.71	18.14	20.02	19.90	20.37	17.93	16.96	20.71	18.93	19.75
Electric Generators[13]											
Fossil Fuel Average	1.48	1.63	1.54	1.61	1.48	1.58	1.59	1.42	1.98	1.48	1.85
Petroleum Products	2.48	3.60	3.69	4.01	3.80	4.04	3.96	4.03	4.22	4.17	4.24
Distillate Fuel	4.07	4.65	4.63	4.74	4.62	4.65	4.85	4.85	4.90	4.78	4.86
Residual Fuel	2.39	3.43	3.50	3.86	3.66	3.90	3.70	3.75	4.09	4.04	4.13
Natural Gas	2.57	3.42	3.24	3.49	3.05	3.38	3.23	2.83	3.60	2.81	3.42
Steam Coal	1.21	1.13	1.13	1.05	1.11	1.04	1.06	1.05	1.00	1.02	1.00

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
13.51	**12.85**	**14.22**	**13.19**	**13.54**	**13.62**	**12.74**	**13.88**	**12.98**	**13.20**
7.05	6.70	7.02	6.59	6.87	7.01	6.50	6.78	6.36	6.60
9.35	9.33	9.14	9.17	9.15	9.47	9.38	9.26	9.02	9.07
7.54	7.46	7.42	7.46	7.47	7.76	7.58	7.55	7.51	7.48
12.84	13.01	12.46	12.49	12.37	12.71	12.96	12.52	11.90	12.13
6.59	6.18	6.60	6.10	6.43	6.56	5.98	6.32	5.88	6.15
22.20	22.16	25.55	23.69	24.07	22.16	22.32	25.20	24.00	24.06
12.39	**11.55**	**13.66**	**12.40**	**12.75**	**12.55**	**11.66**	**13.28**	**12.43**	**12.62**
5.62	5.27	5.60	5.16	5.44	5.69	5.18	5.45	5.03	5.27
6.23	6.20	6.06	6.18	6.16	6.37	6.29	6.16	6.15	6.16
5.30	5.24	5.18	5.23	5.23	5.51	5.36	5.31	5.27	5.24
3.78	3.75	3.73	3.74	3.74	3.85	3.82	3.80	3.81	3.81
5.61	5.20	5.60	5.08	5.41	5.67	5.08	5.42	4.95	5.22
18.78	18.06	22.34	19.90	20.27	18.83	18.41	21.94	20.22	20.31
5.65	**5.40**	**6.00**	**5.57**	**5.77**	**5.82**	**5.47**	**5.96**	**5.58**	**5.73**
4.47	4.25	4.34	4.15	4.31	4.61	4.26	4.35	4.07	4.23
6.01	5.98	5.80	5.80	5.80	6.12	6.01	5.90	5.64	5.71
5.49	5.43	5.39	5.43	5.43	5.71	5.56	5.53	5.48	5.45
7.79	7.87	7.36	7.33	7.30	7.68	7.80	7.44	6.71	6.96
3.51	3.50	3.49	3.50	3.50	3.58	3.58	3.57	3.58	3.58
3.56	3.12	3.53	3.00	3.34	3.73	3.11	3.46	2.99	3.26
1.49	1.48	1.50	1.47	1.47	1.44	1.44	1.45	1.42	1.42
1.25	1.24	1.16	1.21	1.15	1.21	1.20	1.10	1.11	1.10
11.97	11.52	15.78	13.29	13.67	12.07	11.77	15.57	13.63	13.71
9.28	**9.18**	**9.17**	**8.70**	**8.69**	**9.20**	**9.09**	**9.09**	**8.50**	**8.50**
9.26	9.16	9.14	8.67	8.66	9.18	9.07	9.06	8.47	8.47
9.26	9.16	9.13	8.67	8.66	9.18	9.07	9.06	8.47	8.46
8.88	8.83	8.75	8.79	8.79	8.83	8.77	8.73	8.62	8.61
5.54	5.45	5.41	5.31	5.30	5.72	5.61	5.59	5.42	5.43
10.70	10.61	10.61	10.03	10.02	10.60	10.52	10.51	9.82	9.81
3.26	3.37	3.36	3.38	3.38	3.33	3.48	3.48	3.49	3.49
13.94	14.08	13.60	13.58	13.46	13.64	13.88	13.53	12.91	13.10
7.28	6.86	7.27	6.65	6.97	7.30	6.73	7.04	6.48	6.74
19.27	17.79	17.79	16.97	16.97	19.34	16.31	16.32	15.63	15.66
14.17	14.30	14.30	14.14	13.89	14.35	14.38	14.38	14.14	13.89
13.43	13.39	17.09	15.45	15.84	13.18	13.18	16.34	15.45	15.37
9.08	**8.73**	**9.34**	**8.75**	**8.90**	**9.13**	**8.71**	**9.20**	**8.63**	**8.73**
7.16	6.98	7.04	6.60	6.71	7.20	6.93	6.99	6.46	6.56
17.93	17.38	21.39	19.05	19.42	17.96	17.56	21.06	19.28	19.35
1.71	1.44	2.01	1.53	1.86	1.85	1.45	2.02	1.60	1.89
4.04	4.08	4.34	4.35	4.42	4.20	4.24	4.47	4.51	4.55
4.83	4.79	4.91	4.95	5.02	5.05	4.90	5.12	5.06	5.12
3.79	3.84	4.21	4.21	4.31	3.92	3.98	4.33	4.39	4.44
3.39	2.85	3.55	2.86	3.32	3.62	2.86	3.50	2.91	3.27
1.02	1.00	0.94	0.98	0.93	0.98	0.96	0.92	0.93	0.89

Table D3. Energy Prices by Sector and Source (Continued)

(1999 Dollars per Million Btu, Unless Otherwise Noted)

Sector and Source	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Average Price to All Users[14]											
Petroleum Products[2]	7.46	8.48	8.46	8.47	8.06	8.06	8.75	8.74	8.73	8.01	8.06
Distillate Fuel	7.25	8.06	8.03	8.00	7.87	7.87	8.20	8.23	8.19	7.99	8.01
Jet Fuel	4.70	5.22	5.21	5.18	5.05	5.05	5.49	5.49	5.48	5.19	5.22
Liquefied Petroleum Gas	8.84	8.65	8.64	8.63	8.60	8.55	8.66	8.66	8.53	7.85	8.33
Motor Gasoline[8]	9.45	10.75	10.70	10.71	10.07	10.07	11.20	11.19	11.21	10.14	10.14
Residual Fuel	2.47	3.25	3.26	3.25	3.26	3.25	3.33	3.37	3.37	3.37	3.37
Natural Gas	4.04	4.73	4.61	4.66	4.39	4.56	4.43	4.17	4.54	4.02	4.42
Coal	1.23	1.15	1.14	1.07	1.13	1.07	1.08	1.07	1.03	1.04	1.02
Ethanol (E85)[11]	14.42	19.20	19.16	19.17	18.96	18.99	19.13	19.07	19.11	18.75	18.79
Methanol (M85)[12]	10.38	13.13	12.97	13.00	12.90	12.76	13.80	13.79	13.80	13.53	13.59
Electricity	19.58	18.71	18.14	20.02	19.90	20.37	17.93	16.96	20.71	18.93	19.75
Non-Renewable Energy Expenditures by Sector (billion 1999 dollars)											
Residential	135.11	154.23	149.03	153.94	149.50	151.80	158.26	147.30	158.11	146.97	150.79
Commercial	99.11	115.32	107.70	115.39	114.29	116.55	119.82	106.18	122.46	113.78	118.43
Industrial	112.11	126.41	121.68	127.64	123.22	125.87	131.84	121.55	137.47	120.88	128.26
Transportation	212.64	271.38	267.23	266.79	238.47	238.22	306.12	299.58	299.43	249.63	249.73
Total Non-Renewable Expenditures	558.97	667.34	645.64	663.76	625.47	632.44	716.05	674.61	717.47	631.26	647.22
Transportation Renewable Expenditures	0.14	0.42	0.42	0.42	0.40	0.40	0.62	0.64	0.64	0.53	0.52
Total Expenditures	**559.11**	**667.75**	**646.06**	**664.18**	**625.87**	**632.84**	**716.67**	**675.24**	**718.11**	**631.79**	**647.74**

[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 excludes county and local taxes.
[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.
CEF = Clean Energy Future.
Note: Data for 1999 are model results and may differ slightly from official EIA data reports.

Sources: 1999 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(99/03-2000/04) (Washington, DC, 1999-2000). 1999 prices for all other petroleum products are derived from the EIA, *State Energy Price and Expenditure Report 1997*, DOE/EIA-0376(97) (Washington, DC, July 2000). 1999 industrial gas delivered prices are based on EIA, *Manufacturing Energy Consumption Survey 1994*. 1999 residential and commercial natural gas delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). 1999 coal prices based on EIA, *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000) and EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. 1999 electricity prices for commercial, industrial, and transportation: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
8.50	8.43	8.37	7.99	7.99	8.49	8.39	8.35	7.81	7.82
8.16	8.09	8.02	8.07	8.07	8.20	8.09	8.05	7.97	7.95
5.54	5.45	5.41	5.31	5.30	5.72	5.61	5.59	5.42	5.43
8.63	8.75	8.25	8.21	8.16	8.48	8.64	8.29	7.57	7.81
10.70	10.61	10.61	10.02	10.01	10.60	10.51	10.51	9.82	9.81
3.41	3.47	3.47	3.48	3.48	3.49	3.58	3.57	3.58	3.58
4.41	4.06	4.44	3.97	4.26	4.50	3.97	4.32	3.88	4.12
1.04	1.02	0.97	1.00	0.95	0.99	0.98	0.95	0.95	0.91
19.27	17.79	17.79	16.97	16.97	19.34	16.31	16.32	15.63	15.66
14.17	14.30	14.30	14.14	13.89	14.35	14.38	14.38	14.14	13.89
17.93	17.38	21.39	19.05	19.42	17.96	17.56	21.06	19.28	19.35
167.03	151.11	161.49	145.00	147.17	177.68	154.78	163.27	144.71	145.78
128.83	112.29	129.63	117.72	119.92	135.53	115.34	129.39	119.34	120.23
139.94	128.69	144.02	127.32	131.32	152.08	136.38	149.45	132.17	135.34
319.67	306.38	305.39	255.44	255.08	340.13	321.55	320.86	259.97	259.56
755.47	698.47	740.53	645.49	653.49	805.42	728.05	762.97	656.20	660.91
0.74	0.77	0.76	0.67	0.67	0.85	0.93	0.93	0.79	0.79
756.21	**699.23**	**741.29**	**646.16**	**654.16**	**806.27**	**728.98**	**763.90**	**656.99**	**661.70**

Table D4. Residential Sector Key Indicators and End-Use Consumption
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Key Indicators											
Households (millions)											
Single-Family	75.70	81.28	81.28	81.28	81.26	81.25	85.38	85.39	85.38	85.36	85.36
Multifamily	21.79	23.06	23.06	23.06	23.04	23.04	24.16	24.17	24.16	24.14	24.13
Mobile Homes	6.59	6.93	6.93	6.93	6.93	6.93	7.19	7.20	7.19	7.19	7.19
Total	**104.08**	**111.26**	**111.27**	**111.26**	**111.22**	**111.22**	**116.74**	**116.75**	**116.73**	**116.70**	**116.68**
Average House Square Footage	**1673**	**1702**	**1702**	**1702**	**1702**	**1702**	**1724**	**1724**	**1724**	**1724**	**1724**
Energy Intensity											
(million Btu per household)											
Delivered Energy Consumption	102.4	107.7	106.8	105.4	103.9	103.3	104.7	102.2	99.2	98.1	96.8
Total Energy Consumption	183.5	194.5	192.5	185.5	185.7	183.0	190.3	184.6	172.6	173.4	168.7
(thousand Btu per square foot)											
Delivered Energy Consumption	61.2	63.3	62.7	61.9	61.0	60.7	60.7	59.3	57.6	56.9	56.2
Total Energy Consumption	109.7	114.3	113.1	109.0	109.1	107.5	110.4	107.1	100.2	100.6	97.9
Delivered Energy Consumption by Fuel											
Electricity											
Space Heating	0.38	0.45	0.46	0.44	0.43	0.43	0.47	0.48	0.44	0.44	0.44
Space Cooling	0.54	0.57	0.58	0.56	0.55	0.54	0.60	0.60	0.56	0.53	0.53
Water Heating	0.39	0.42	0.42	0.41	0.40	0.40	0.42	0.39	0.35	0.36	0.36
Refrigeration	0.42	0.38	0.38	0.38	0.38	0.38	0.34	0.33	0.33	0.33	0.33
Cooking	0.10	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12
Clothes Dryers	0.21	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.24	0.25	0.25
Freezers	0.12	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
Lighting	0.34	0.41	0.41	0.40	0.38	0.38	0.46	0.46	0.43	0.40	0.39
Clothes Washers[1]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dishwashers[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Color Televisions	0.12	0.17	0.16	0.16	0.16	0.16	0.19	0.18	0.17	0.17	0.17
Personal Computers	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Furnace Fans	0.07	0.09	0.09	0.09	0.08	0.08	0.10	0.10	0.09	0.09	0.09
Other Uses[2]	1.10	1.48	1.39	1.36	1.36	1.35	1.73	1.50	1.44	1.46	1.44
Delivered Energy	**3.91**	**4.56**	**4.48**	**4.37**	**4.34**	**4.31**	**4.91**	**4.64**	**4.40**	**4.39**	**4.34**
Natural Gas											
Space Heating	3.24	3.76	3.76	3.72	3.63	3.61	3.77	3.79	3.69	3.62	3.55
Space Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Heating	1.27	1.37	1.35	1.35	1.35	1.34	1.34	1.32	1.30	1.31	1.29
Cooking	0.19	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Clothes Dryers	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.08
Other Uses[3]	0.11	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11
Delivered Energy	**4.88**	**5.55**	**5.53**	**5.49**	**5.40**	**5.36**	**5.54**	**5.54**	**5.42**	**5.36**	**5.26**
Distillate											
Space Heating	0.73	0.74	0.74	0.74	0.72	0.72	0.69	0.69	0.69	0.65	0.65
Water Heating	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11
Other Uses[4]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delivered Energy	**0.86**	**0.87**	**0.87**	**0.87**	**0.84**	**0.84**	**0.80**	**0.79**	**0.80**	**0.76**	**0.76**
Liquefied Petroleum Gas											
Space Heating	0.31	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28
Water Heating	0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
Cooking	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Other Uses[3]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Delivered Energy	**0.46**	**0.46**	**0.45**	**0.45**	**0.44**	**0.44**	**0.43**	**0.42**	**0.42**	**0.41**	**0.41**
Marketed Renewables (wood)[5]	0.41	0.42	0.42	0.42	0.41	0.41	0.42	0.42	0.42	0.41	0.41
Other Fuels[6]	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
89.83	89.84	89.82	89.81	89.80	94.28	94.29	94.28	94.26	94.26
25.62	25.62	25.61	25.60	25.59	27.03	27.03	27.02	27.01	27.00
7.57	7.57	7.57	7.57	7.57	7.97	7.97	7.97	7.97	7.97
123.02	**123.03**	**123.01**	**122.97**	**122.97**	**129.28**	**129.29**	**129.27**	**129.24**	**129.23**
1744	**1744**	**1744**	**1744**	**1744**	**1763**	**1763**	**1763**	**1763**	**1763**
104.0	99.1	95.8	92.8	91.8	104.3	97.4	94.3	89.5	88.7
187.6	175.8	163.4	159.1	155.3	186.7	170.2	158.9	148.4	145.9
59.6	56.8	54.9	53.2	52.6	59.2	55.2	53.5	50.8	50.3
107.6	100.8	93.7	91.2	89.1	105.9	96.6	90.1	84.2	82.8
0.49	0.49	0.45	0.45	0.45	0.51	0.51	0.46	0.45	0.45
0.64	0.60	0.56	0.53	0.53	0.71	0.63	0.59	0.56	0.56
0.41	0.35	0.29	0.32	0.31	0.41	0.29	0.23	0.25	0.25
0.32	0.29	0.29	0.28	0.27	0.32	0.27	0.27	0.24	0.24
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
0.26	0.26	0.25	0.26	0.26	0.28	0.27	0.27	0.27	0.27
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
0.49	0.47	0.44	0.39	0.38	0.52	0.49	0.45	0.37	0.37
0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03
0.21	0.19	0.18	0.18	0.18	0.24	0.21	0.20	0.19	0.19
0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11
0.11	0.10	0.10	0.09	0.09	0.12	0.11	0.11	0.09	0.09
1.97	1.57	1.50	1.40	1.39	2.21	1.64	1.57	1.37	1.37
5.27	**4.68**	**4.41**	**4.24**	**4.21**	**5.69**	**4.79**	**4.53**	**4.19**	**4.18**
3.98	4.02	3.89	3.76	3.69	4.24	4.31	4.17	3.98	3.90
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.35	1.33	1.31	1.33	1.31	1.37	1.33	1.32	1.33	1.31
0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25
0.09	0.10	0.09	0.09	0.09	0.10	0.11	0.10	0.10	0.10
0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
5.78	**5.79**	**5.65**	**5.53**	**5.44**	**6.08**	**6.11**	**5.97**	**5.77**	**5.68**
0.67	0.67	0.67	0.63	0.63	0.66	0.65	0.66	0.61	0.61
0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.78	**0.77**	**0.77**	**0.72**	**0.72**	**0.76**	**0.75**	**0.75**	**0.70**	**0.70**
0.29	0.28	0.28	0.26	0.27	0.29	0.27	0.28	0.26	0.26
0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.41	**0.40**	**0.41**	**0.38**	**0.38**	**0.41**	**0.39**	**0.40**	**0.37**	**0.37**
0.43	0.43	0.42	0.42	0.41	0.43	0.44	0.42	0.43	0.42
0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.11

Table D4. Residential Sector Key Indicators and End-Use Consumption (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Delivered Energy Consumption by End-Use											
Space Heating	5.21	5.81	5.82	5.76	5.62	5.59	5.77	5.79	5.65	5.53	5.45
Space Cooling	0.54	0.58	0.58	0.56	0.55	0.55	0.60	0.60	0.56	0.54	0.53
Water Heating	1.90	2.02	1.99	1.98	1.97	1.95	1.96	1.90	1.85	1.87	1.84
Refrigeration	0.42	0.38	0.38	0.38	0.38	0.38	0.34	0.33	0.33	0.33	0.33
Cooking	0.32	0.37	0.36	0.37	0.37	0.36	0.37	0.37	0.37	0.37	0.37
Clothes Dryers	0.28	0.32	0.32	0.32	0.32	0.32	0.34	0.34	0.33	0.33	0.33
Freezers	0.12	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
Lighting	0.34	0.41	0.41	0.40	0.38	0.38	0.46	0.46	0.43	0.40	0.39
Clothes Washers	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dishwashers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Color Televisions	0.12	0.17	0.16	0.16	0.16	0.16	0.19	0.18	0.17	0.17	0.17
Personal Computers	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Furnace Fans	0.07	0.09	0.09	0.09	0.08	0.08	0.10	0.10	0.09	0.09	0.09
Other Uses[7]	1.22	1.60	1.52	1.49	1.49	1.48	1.85	1.63	1.56	1.58	1.56
Delivered Energy	**10.66**	**11.99**	**11.88**	**11.73**	**11.55**	**11.49**	**12.22**	**11.93**	**11.58**	**11.44**	**11.30**
Electricity Related Losses	**8.44**	**9.66**	**9.54**	**8.91**	**9.10**	**8.85**	**10.00**	**9.62**	**8.57**	**8.79**	**8.39**
Total Energy Consumption by End-Use											
Space Heating	6.02	6.77	6.81	6.65	6.53	6.48	6.72	6.79	6.50	6.41	6.29
Space Cooling	1.70	1.79	1.81	1.69	1.70	1.66	1.82	1.84	1.66	1.60	1.55
Water Heating	2.75	2.90	2.88	2.81	2.82	2.78	2.82	2.71	2.54	2.60	2.53
Refrigeration	1.34	1.18	1.18	1.15	1.17	1.15	1.04	1.02	0.97	0.99	0.97
Cooking	0.54	0.60	0.61	0.60	0.60	0.60	0.62	0.62	0.61	0.61	0.60
Clothes Dryers	0.75	0.83	0.84	0.80	0.82	0.80	0.85	0.86	0.81	0.83	0.81
Freezers	0.37	0.30	0.30	0.30	0.30	0.30	0.27	0.27	0.26	0.27	0.26
Lighting	1.07	1.27	1.29	1.21	1.19	1.16	1.39	1.41	1.26	1.20	1.15
Clothes Washers	0.09	0.10	0.09	0.09	0.09	0.09	0.10	0.08	0.08	0.08	0.07
Dishwashers	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Color Televisions	0.38	0.52	0.50	0.48	0.49	0.48	0.57	0.54	0.50	0.52	0.50
Personal Computers	0.20	0.29	0.30	0.28	0.29	0.28	0.28	0.29	0.27	0.28	0.27
Furnace Fans	0.23	0.27	0.27	0.26	0.26	0.26	0.29	0.30	0.27	0.28	0.27
Other Uses[7]	3.59	4.73	4.48	4.26	4.33	4.25	5.37	4.74	4.36	4.49	4.34
Total	**19.10**	**21.65**	**21.42**	**20.64**	**20.65**	**20.35**	**22.22**	**21.55**	**20.15**	**20.23**	**19.69**
Non-Marketed Renewables											
Geothermal[8]	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
Solar[9]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**

[1]Does not include electric water heating portion of load.
[2]Includes small electric devices, heating elements, and motors.
[3]Includes such appliances as swimming pool heaters, outdoor grills, and outdoor lighting (natural gas).
[4]Includes such appliances as swimming pool and hot tub heaters.
[5]Includes wood used for primary and secondary heating in wood stoves or fireplaces as reported in the *Residential Energy Consumption Survey 1997*.
[6]Includes kerosene and coal.
[7]Includes all other uses listed above.
[8]Includes primary energy displaced by geothermal heat pumps in space heating and cooling applications.
[9]Includes primary energy displaced by solar thermal water heaters and electricity generated using photovoltaics.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999: Energy Information Administration (EIA), *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
5.97	6.00	5.83	5.63	5.55	6.24	6.30	6.12	5.84	5.76
0.64	0.60	0.57	0.53	0.53	0.71	0.63	0.60	0.57	0.57
1.96	1.85	1.79	1.81	1.79	1.96	1.78	1.72	1.74	1.72
0.32	0.29	0.29	0.28	0.27	0.32	0.27	0.27	0.24	0.24
0.40	0.39	0.40	0.39	0.39	0.42	0.42	0.42	0.42	0.42
0.36	0.36	0.35	0.35	0.35	0.38	0.38	0.37	0.37	0.37
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
0.49	0.47	0.44	0.39	0.38	0.52	0.49	0.45	0.37	0.37
0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03
0.21	0.19	0.18	0.18	0.18	0.24	0.21	0.20	0.19	0.19
0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11
0.11	0.10	0.10	0.09	0.09	0.12	0.11	0.11	0.09	0.09
2.09	1.69	1.62	1.52	1.51	2.32	1.76	1.69	1.49	1.48
12.79	**12.19**	**11.78**	**11.41**	**11.28**	**13.48**	**12.59**	**12.19**	**11.57**	**11.46**
10.28	**9.44**	**8.32**	**8.16**	**7.81**	**10.65**	**9.42**	**8.35**	**7.61**	**7.39**
6.92	7.00	6.67	6.49	6.38	7.20	7.31	6.98	6.67	6.57
1.89	1.81	1.63	1.55	1.51	2.03	1.86	1.69	1.59	1.56
2.76	2.55	2.34	2.42	2.36	2.72	2.35	2.15	2.20	2.16
0.95	0.87	0.83	0.80	0.78	0.93	0.80	0.76	0.68	0.67
0.64	0.65	0.63	0.64	0.63	0.66	0.68	0.66	0.66	0.65
0.87	0.88	0.82	0.84	0.82	0.89	0.91	0.86	0.86	0.85
0.25	0.26	0.25	0.25	0.24	0.25	0.26	0.25	0.24	0.24
1.44	1.42	1.26	1.13	1.09	1.49	1.44	1.29	1.05	1.03
0.09	0.07	0.06	0.06	0.06	0.08	0.06	0.06	0.06	0.06
0.08	0.08	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.07
0.63	0.58	0.53	0.53	0.51	0.69	0.62	0.57	0.54	0.53
0.29	0.30	0.28	0.29	0.28	0.33	0.34	0.31	0.32	0.31
0.31	0.31	0.29	0.27	0.27	0.33	0.33	0.30	0.27	0.26
5.94	4.85	4.44	4.22	4.10	6.45	4.97	4.59	3.97	3.90
23.08	**21.63**	**20.10**	**19.57**	**19.10**	**24.14**	**22.01**	**20.54**	**19.18**	**18.85**
0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.04	**0.03**	**0.03**	**0.03**	**0.03**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**

Table D5. Commercial Sector Key Indicators and Consumption
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Key Indicators											
Total Floor Space (billion square feet)											
Surviving	60.8	69.0	69.0	69.0	69.0	69.0	74.0	74.0	74.0	74.0	74.0
New Additions	2.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Total	**62.8**	**70.9**	**70.9**	**70.9**	**70.9**	**70.9**	**75.8**	**75.8**	**75.8**	**75.8**	**75.8**
Energy Consumption Intensity (thousand Btu per square foot)											
Delivered Energy Consumption	120.2	129.2	125.8	124.6	124.4	123.6	130.4	124.8	121.9	123.6	122.0
Electricity Related Losses	126.0	131.7	126.6	119.1	123.4	120.1	132.3	124.8	113.1	119.3	113.9
Total Energy Consumption	246.2	260.9	252.5	243.7	247.9	243.7	262.7	249.7	235.1	242.9	235.9
Delivered Energy Consumption by Fuel											
Purchased Electricity											
Space Heating[1]	0.14	0.16	0.16	0.15	0.14	0.14	0.16	0.16	0.15	0.14	0.14
Space Cooling[1]	0.45	0.44	0.41	0.40	0.40	0.40	0.45	0.40	0.38	0.39	0.39
Water Heating[1]	0.14	0.15	0.15	0.14	0.15	0.15	0.16	0.15	0.14	0.15	0.15
Ventilation	0.17	0.19	0.18	0.18	0.18	0.17	0.20	0.18	0.17	0.18	0.17
Cooking	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Lighting	1.21	1.31	1.22	1.17	1.21	1.19	1.40	1.27	1.18	1.27	1.25
Refrigeration	0.18	0.20	0.20	0.19	0.19	0.19	0.21	0.20	0.20	0.20	0.20
Office Equipment (PC)	0.10	0.18	0.18	0.18	0.18	0.18	0.24	0.25	0.25	0.25	0.25
Office Equipment (non-PC)	0.30	0.41	0.40	0.40	0.40	0.40	0.51	0.51	0.50	0.51	0.51
Other Uses[2]	0.94	1.34	1.29	1.28	1.29	1.28	1.56	1.40	1.39	1.40	1.39
Delivered Energy	**3.66**	**4.40**	**4.22**	**4.13**	**4.17**	**4.14**	**4.92**	**4.56**	**4.40**	**4.51**	**4.47**
Natural Gas[3]											
Space Heating[1]	1.42	1.64	1.60	1.60	1.57	1.55	1.71	1.66	1.62	1.66	1.62
Space Cooling[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Water Heating[1]	0.64	0.70	0.68	0.68	0.67	0.67	0.76	0.73	0.72	0.72	0.71
Cooking	0.21	0.23	0.23	0.23	0.23	0.22	0.25	0.25	0.25	0.25	0.24
Other Uses[4]	0.86	1.40	1.40	1.40	1.43	1.42	1.45	1.44	1.44	1.46	1.45
Delivered Energy	**3.14**	**3.99**	**3.94**	**3.93**	**3.92**	**3.88**	**4.19**	**4.12**	**4.05**	**4.12**	**4.04**
Distillate											
Space Heating[1]	0.23	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.27	0.24	0.25
Water Heating[1]	0.09	0.09	0.09	0.09	0.08	0.08	0.09	0.09	0.09	0.08	0.08
Other Uses[5]	0.04	0.03	0.02	0.02	0.01	0.01	0.03	0.03	0.03	0.01	0.01
Delivered Energy	**0.36**	**0.37**	**0.38**	**0.38**	**0.35**	**0.35**	**0.38**	**0.38**	**0.39**	**0.34**	**0.34**
Other Fuels[6]	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**
Marketed Renewable Fuels											
Biomass	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Delivered Energy	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Delivered Energy Consumption by End-											
Space Heating[1]	1.79	2.06	2.02	2.01	1.97	1.95	2.14	2.09	2.05	2.04	2.01
Space Cooling[1]	0.46	0.46	0.43	0.42	0.42	0.42	0.47	0.43	0.41	0.42	0.42
Water Heating[1]	0.87	0.94	0.92	0.92	0.90	0.90	1.00	0.97	0.95	0.95	0.94
Ventilation	0.17	0.19	0.18	0.18	0.18	0.17	0.20	0.18	0.17	0.18	0.17
Cooking	0.24	0.26	0.26	0.26	0.26	0.25	0.28	0.29	0.28	0.28	0.27
Lighting	1.21	1.31	1.22	1.17	1.21	1.19	1.40	1.27	1.18	1.27	1.25
Refrigeration	0.18	0.20	0.20	0.19	0.19	0.19	0.21	0.20	0.20	0.20	0.20
Office Equipment (PC)	0.10	0.18	0.18	0.18	0.18	0.18	0.24	0.25	0.25	0.25	0.25
Office Equipment (non-PC)	0.30	0.41	0.40	0.40	0.40	0.40	0.51	0.51	0.50	0.51	0.51
Other Uses[7]	2.23	3.15	3.10	3.09	3.10	3.09	3.43	3.26	3.24	3.26	3.23
Delivered Energy	**7.55**	**9.15**	**8.92**	**8.83**	**8.82**	**8.76**	**9.88**	**9.46**	**9.24**	**9.36**	**9.24**

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
78.1	78.1	78.1	78.1	78.1	80.7	80.7	80.7	80.7	80.7
1.5	1.5	1.5	1.5	1.5	1.3	1.3	1.3	1.3	1.3
79.6	**79.6**	**79.6**	**79.6**	**79.6**	**81.9**	**81.9**	**81.9**	**81.9**	**81.9**
131.7	123.1	120.3	120.3	119.2	132.8	121.8	119.9	118.2	117.3
131.0	120.9	108.2	112.6	108.0	128.9	116.3	104.1	103.7	100.7
262.7	244.0	228.4	232.9	227.2	261.7	238.1	224.0	221.9	217.9
0.16	0.16	0.15	0.13	0.13	0.16	0.16	0.15	0.12	0.12
0.46	0.39	0.37	0.38	0.38	0.46	0.37	0.35	0.36	0.36
0.16	0.14	0.13	0.14	0.14	0.16	0.14	0.12	0.13	0.13
0.21	0.18	0.17	0.17	0.17	0.21	0.18	0.17	0.17	0.17
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1.45	1.27	1.16	1.23	1.22	1.45	1.24	1.13	1.19	1.18
0.22	0.21	0.20	0.21	0.20	0.22	0.21	0.20	0.21	0.21
0.28	0.30	0.29	0.30	0.30	0.29	0.30	0.29	0.30	0.30
0.60	0.61	0.60	0.61	0.61	0.69	0.68	0.67	0.70	0.70
1.79	1.47	1.46	1.46	1.45	1.98	1.54	1.52	1.47	1.47
5.35	**4.77**	**4.57**	**4.66**	**4.64**	**5.64**	**4.85**	**4.62**	**4.68**	**4.66**
1.77	1.71	1.66	1.73	1.69	1.80	1.74	1.67	1.77	1.74
0.03	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
0.81	0.77	0.75	0.76	0.74	0.84	0.80	0.76	0.78	0.77
0.26	0.27	0.26	0.26	0.25	0.27	0.28	0.27	0.27	0.26
1.49	1.46	1.51	1.42	1.41	1.54	1.50	1.66	1.45	1.44
4.36	**4.25**	**4.21**	**4.20**	**4.13**	**4.47**	**4.36**	**4.40**	**4.31**	**4.25**
0.26	0.26	0.28	0.23	0.23	0.25	0.26	0.28	0.21	0.21
0.09	0.09	0.09	0.08	0.08	0.08	0.09	0.09	0.08	0.08
0.03	0.03	0.03	0.01	0.01	0.03	0.03	0.03	0.01	0.01
0.38	**0.38**	**0.40**	**0.32**	**0.32**	**0.37**	**0.37**	**0.39**	**0.30**	**0.30**
0.32	**0.32**	**0.32**	**0.31**	**0.31**	**0.32**	**0.32**	**0.32**	**0.32**	**0.32**
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
0.08	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
2.19	2.14	2.08	2.08	2.05	2.21	2.15	2.10	2.10	2.07
0.48	0.43	0.41	0.42	0.42	0.48	0.41	0.39	0.40	0.40
1.05	1.01	0.97	0.98	0.97	1.08	1.02	0.97	0.99	0.98
0.21	0.18	0.17	0.17	0.17	0.21	0.18	0.17	0.17	0.17
0.29	0.30	0.29	0.29	0.28	0.30	0.31	0.30	0.30	0.29
1.45	1.27	1.16	1.23	1.22	1.45	1.24	1.13	1.19	1.18
0.22	0.21	0.20	0.21	0.20	0.22	0.21	0.20	0.21	0.21
0.28	0.30	0.29	0.30	0.30	0.29	0.30	0.29	0.30	0.30
0.60	0.61	0.60	0.61	0.61	0.69	0.68	0.67	0.70	0.70
3.71	3.36	3.40	3.29	3.27	3.96	3.47	3.61	3.34	3.32
10.48	**9.80**	**9.57**	**9.58**	**9.49**	**10.88**	**9.98**	**9.83**	**9.68**	**9.61**

Table D5. Commercial Sector Key Indicators and Consumption (Continued)
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Electricity Related Losses	**7.91**	**9.33**	**8.97**	**8.44**	**8.75**	**8.51**	**10.02**	**9.46**	**8.57**	**9.04**	**8.63**
Total Energy Consumption by End-Use											
Space Heating[1]	2.09	2.39	2.35	2.32	2.27	2.25	2.47	2.42	2.34	2.32	2.27
Space Cooling[1]	1.43	1.38	1.31	1.24	1.26	1.24	1.39	1.27	1.16	1.20	1.17
Water Heating[1]	1.18	1.27	1.24	1.21	1.21	1.20	1.33	1.28	1.22	1.25	1.22
Ventilation	0.55	0.59	0.56	0.53	0.54	0.53	0.61	0.56	0.51	0.53	0.51
Cooking	0.31	0.32	0.33	0.32	0.32	0.32	0.34	0.35	0.34	0.34	0.33
Lighting	3.81	4.09	3.80	3.56	3.73	3.65	4.25	3.91	3.49	3.81	3.65
Refrigeration	0.58	0.63	0.61	0.59	0.60	0.59	0.65	0.63	0.59	0.61	0.59
Office Equipment (PC)	0.33	0.55	0.57	0.55	0.56	0.56	0.72	0.78	0.74	0.75	0.73
Office Equipment (non-PC)	0.93	1.28	1.26	1.22	1.25	1.23	1.54	1.56	1.48	1.52	1.48
Other Uses[7]	4.25	5.98	5.85	5.71	5.81	5.72	6.61	6.16	5.94	6.06	5.92
Total	**15.46**	**18.48**	**17.89**	**17.27**	**17.56**	**17.27**	**19.90**	**18.91**	**17.81**	**18.40**	**17.87**
Non-Marketed Renewable Fuels											
Solar[8]	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Total	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**

[1]Includes fuel consumption for district services.
[2]Includes miscellaneous uses, such as service station equipment, automated teller machines, telecommunications equipment, and medical equipment.
[3]Excludes estimated consumption from independent power producers.
[4]Includes miscellaneous uses, such as pumps, emergency electric generators, cogeneration in commercial buildings, and manufacturing performed in commercial buildings.
[5]Includes miscellaneous uses, such as cooking, emergency electric generators, and cogeneration in commercial buildings.
[6]Includes residual fuel oil, liquefied petroleum gas, coal, motor gasoline, and kerosene.
[7]Includes miscellaneous uses, such as service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, lighting, emergency electric generators, cogeneration in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, liquefied petroleum gas, coal, motor gasoline, and kerosene.
[8]Includes primary energy displaced by solar thermal space heating and water heating, and electricity generation by solar photovoltaic systems.
Btu = British thermal unit.
PC = Personal computer.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999: Energy Information Administration (EIA), *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
10.43	**9.63**	**8.61**	**8.97**	**8.60**	**10.56**	**9.53**	**8.53**	**8.50**	**8.25**
2.51	2.46	2.36	2.33	2.29	2.51	2.46	2.36	2.32	2.29
1.38	1.22	1.10	1.15	1.12	1.34	1.14	1.04	1.06	1.05
1.36	1.30	1.22	1.25	1.23	1.37	1.29	1.20	1.23	1.21
0.61	0.55	0.49	0.51	0.49	0.60	0.53	0.47	0.48	0.47
0.35	0.36	0.34	0.34	0.34	0.35	0.36	0.35	0.34	0.34
4.28	3.84	3.36	3.60	3.48	4.16	3.67	3.21	3.34	3.26
0.65	0.63	0.58	0.60	0.58	0.64	0.62	0.57	0.58	0.57
0.82	0.90	0.85	0.87	0.85	0.84	0.89	0.84	0.84	0.83
1.77	1.84	1.73	1.79	1.74	1.98	2.03	1.91	1.96	1.93
7.19	6.34	6.15	6.10	5.96	7.67	6.50	6.41	6.02	5.92
20.91	**19.43**	**18.19**	**18.54**	**18.09**	**21.44**	**19.51**	**18.35**	**18.18**	**17.86**
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.03	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**

Table D6. Industrial Sector Key Indicators and Consumption
(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Key Indicators											
Value of Gross Output (billion 1992 dollars)											
Manufacturing	3749	4372	4371	4367	4362	4360	5061	5059	5061	5055	5053
Nonmanufacturing	972	1067	1063	1060	1056	1055	1162	1156	1153	1150	1149
Total	**4722**	**5438**	**5434**	**5428**	**5418**	**5414**	**6223**	**6215**	**6214**	**6205**	**6203**
Energy Prices (1999 dollars per million Btu)											
Electricity	13.12	12.81	12.38	14.17	14.16	14.53	12.04	11.15	15.09	13.18	14.01
Natural Gas	2.79	3.66	3.50	3.54	3.24	3.44	3.46	3.12	3.56	2.96	3.42
Steam Coal	1.43	1.35	1.34	1.31	1.34	1.30	1.30	1.29	1.20	1.27	1.19
Residual Oil	2.78	3.37	3.36	3.34	3.35	3.34	3.43	3.42	3.42	3.42	3.42
Distillate Oil	4.65	5.33	5.30	5.25	5.14	5.14	5.53	5.52	5.45	5.28	5.30
Liquefied Petroleum Gas	8.50	7.75	7.73	7.72	7.68	7.64	7.77	7.75	7.62	6.94	7.43
Motor Gasoline	9.42	10.73	10.66	10.67	10.02	10.02	11.19	11.12	11.16	10.07	10.07
Metallurgical Coal	1.66	1.58	1.58	1.59	1.59	1.58	1.54	1.54	1.55	1.53	1.53
Energy Consumption											
Consumption[1]											
Purchased Electricity	3.61	3.88	3.83	3.78	3.75	3.74	4.16	4.08	3.88	3.89	3.87
Natural Gas[2]	9.80	10.42	10.29	10.32	10.21	10.19	11.27	10.99	11.20	10.74	10.69
Steam Coal	1.73	1.80	1.79	1.80	1.71	1.72	1.82	1.79	1.74	1.64	1.60
Metallurgical Coal and Coke[3]	0.81	0.78	0.77	0.77	0.76	0.76	0.76	0.75	0.75	0.73	0.73
Residual Fuel	0.22	0.16	0.16	0.16	0.15	0.15	0.25	0.24	0.25	0.20	0.22
Distillate	1.13	1.21	1.20	1.19	1.18	1.18	1.30	1.27	1.26	1.24	1.24
Liquefied Petroleum Gas	2.32	2.44	2.38	2.39	2.33	2.35	2.51	2.39	2.40	2.35	2.36
Petrochemical Feedstocks	1.29	1.36	1.33	1.33	1.31	1.31	1.53	1.46	1.46	1.43	1.43
Other Petroleum[4]	4.50	4.64	4.61	4.62	4.55	4.55	4.92	4.81	4.86	4.72	4.74
Renewables[5]	2.15	2.40	2.39	2.39	2.43	2.43	2.63	2.60	2.60	2.75	2.75
Delivered Energy	**27.56**	**29.10**	**28.75**	**28.74**	**28.40**	**28.39**	**31.14**	**30.38**	**30.41**	**29.68**	**29.63**
Electricity Related Losses	7.80	8.21	8.16	7.73	7.87	7.68	8.47	8.46	7.56	7.79	7.48
Total	**35.36**	**37.31**	**36.91**	**36.47**	**36.27**	**36.06**	**39.61**	**38.83**	**37.97**	**37.46**	**37.10**
Consumption per Unit of Output[1] (thousand Btu per 1992 dollars)											
Purchased Electricity	0.76	0.71	0.71	0.70	0.69	0.69	0.67	0.66	0.62	0.63	0.62
Natural Gas[2]	2.08	1.92	1.89	1.90	1.88	1.88	1.81	1.77	1.80	1.73	1.72
Steam Coal	0.37	0.33	0.33	0.33	0.32	0.32	0.29	0.29	0.28	0.26	0.26
Metallurgical Coal and Coke[3]	0.17	0.14	0.14	0.14	0.14	0.14	0.12	0.12	0.12	0.12	0.12
Residual Fuel	0.05	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.04
Distillate	0.24	0.22	0.22	0.22	0.22	0.22	0.21	0.20	0.20	0.20	0.20
Liquefied Petroleum Gas	0.49	0.45	0.44	0.44	0.43	0.43	0.40	0.38	0.39	0.38	0.38
Petrochemical Feedstocks	0.27	0.25	0.24	0.24	0.24	0.24	0.25	0.24	0.24	0.23	0.23
Other Petroleum[4]	0.95	0.85	0.85	0.85	0.84	0.84	0.79	0.77	0.78	0.76	0.76
Renewables[5]	0.46	0.44	0.44	0.44	0.45	0.45	0.42	0.42	0.42	0.44	0.44
Delivered Energy	**5.84**	**5.35**	**5.29**	**5.30**	**5.24**	**5.24**	**5.00**	**4.89**	**4.89**	**4.78**	**4.78**
Electricity Related Losses	1.65	1.51	1.50	1.42	1.45	1.42	1.36	1.36	1.22	1.25	1.21
Total	**7.49**	**6.86**	**6.79**	**6.72**	**6.69**	**6.66**	**6.37**	**6.25**	**6.11**	**6.04**	**5.98**

[1]Fuel consumption includes consumption for cogeneration.
[2]Includes lease and plant fuel.
[3]Includes net coke coal imports.
[4]Includes petroleum coke, asphalt, road oil, lubricants, motor gasoline, still gas, and miscellaneous petroleum products.
[5]Includes consumption of energy from hydroelectric, wood and wood waste, municipal solid waste, and other biomass.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 prices for gasoline and distillate are based on prices in various issues of Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380 (99/03-2000/04) (Washington, DC, 1999-2000). 1999 coal prices are based on EIA, *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000) and EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. 1999 electricity prices: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. Other 1999 prices derived from EIA, *State Energy Data Report 1997*, DOE/EIA-0214(97) (Washington, DC, September 1999). Other 1999 values: EIA, *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf. **Projections:** EIA, AEO2001 National Energy Modeling System runs

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
5816	5808	5812	5802	5802	6712	6707	6710	6698	6699
1266	1255	1251	1245	1246	1371	1356	1350	1344	1344
7082	**7063**	**7062**	**7047**	**7049**	**8083**	**8062**	**8060**	**8042**	**8043**
11.97	11.52	15.78	13.29	13.67	12.07	11.77	15.57	13.63	13.71
3.56	3.12	3.53	3.00	3.34	3.73	3.11	3.46	2.99	3.26
1.25	1.24	1.16	1.21	1.15	1.21	1.20	1.10	1.11	1.10
3.51	3.50	3.49	3.50	3.50	3.58	3.58	3.57	3.58	3.58
5.49	5.43	5.39	5.43	5.43	5.71	5.56	5.53	5.48	5.45
7.79	7.87	7.36	7.33	7.30	7.68	7.80	7.44	6.71	6.96
10.68	10.52	10.52	9.94	9.93	10.56	10.40	10.39	9.70	9.69
1.49	1.48	1.50	1.47	1.47	1.44	1.44	1.45	1.42	1.42
4.43	4.30	3.94	4.03	4.02	4.76	4.54	4.04	4.18	4.19
12.03	11.57	11.91	11.11	11.06	12.71	12.18	12.66	11.64	11.60
1.84	1.80	1.77	1.62	1.59	1.86	1.81	1.78	1.59	1.57
0.74	0.73	0.73	0.71	0.71	0.72	0.72	0.72	0.69	0.69
0.26	0.25	0.26	0.22	0.22	0.27	0.25	0.26	0.19	0.20
1.39	1.35	1.34	1.30	1.30	1.49	1.43	1.42	1.37	1.37
2.67	2.48	2.51	2.41	2.45	2.85	2.59	2.65	2.51	2.52
1.61	1.51	1.51	1.46	1.46	1.69	1.57	1.57	1.52	1.52
5.08	4.92	4.97	4.81	4.81	5.28	5.05	5.08	4.88	4.91
2.85	2.81	2.81	3.08	3.08	3.07	3.03	3.02	3.43	3.43
32.90	**31.71**	**31.75**	**30.74**	**30.70**	**34.72**	**33.16**	**33.20**	**32.00**	**31.99**
8.64	8.67	7.44	7.74	7.46	8.91	8.92	7.46	7.59	7.41
41.54	**40.38**	**39.19**	**38.48**	**38.16**	**43.63**	**42.08**	**40.66**	**39.59**	**39.40**
0.63	0.61	0.56	0.57	0.57	0.59	0.56	0.50	0.52	0.52
1.70	1.64	1.69	1.58	1.57	1.57	1.51	1.57	1.45	1.44
0.26	0.25	0.25	0.23	0.22	0.23	0.22	0.22	0.20	0.20
0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02
0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.17	0.17
0.38	0.35	0.35	0.34	0.35	0.35	0.32	0.33	0.31	0.31
0.23	0.21	0.21	0.21	0.21	0.21	0.19	0.19	0.19	0.19
0.72	0.70	0.70	0.68	0.68	0.65	0.63	0.63	0.61	0.61
0.40	0.40	0.40	0.44	0.44	0.38	0.38	0.38	0.43	0.43
4.65	**4.49**	**4.50**	**4.36**	**4.36**	**4.30**	**4.11**	**4.12**	**3.98**	**3.98**
1.22	1.23	1.05	1.10	1.06	1.10	1.11	0.93	0.94	0.92
5.87	**5.72**	**5.55**	**5.46**	**5.41**	**5.40**	**5.22**	**5.04**	**4.92**	**4.90**

Table D7. Transportation Sector Key Indicators and Delivered Energy Consumption

Key Indicators and Consumption	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Key Indicators											
Level of Travel (billions)											
Light-Duty Vehicles <8,500 pounds (VMT)	2394	2765	2766	2765	2579	2578	3059	3061	3060	2816	2816
Commercial Light Trucks (VMT)[1]	73	83	83	83	80	80	93	92	92	89	89
Freight Trucks >10,000 pounds (VMT)	204	247	247	247	246	246	279	275	275	275	275
Air (seat miles available)	1099	1305	1309	1308	1296	1294	1586	1594	1594	1588	1586
Rail (ton miles traveled)	1353	1569	1570	1486	1515	1472	1708	1680	1453	1545	1462
Domestic Shipping (ton miles traveled)	661	736	726	721	716	716	778	754	748	739	738
Energy Efficiency Indicators											
New Light-Duty Vehicle (miles per gallon)[2]	24.2	26.1	26.5	26.5	28.8	28.8	27.2	28.0	28.1	31.6	31.6
New Car (miles per gallon)[2]	27.9	30.9	32.2	32.2	34.4	34.4	32.5	34.5	34.5	38.0	38.0
New Light Truck (miles per gallon)[2]	20.8	22.3	22.3	22.3	24.5	24.5	23.3	23.5	23.5	26.9	26.9
Light-Duty Fleet (miles per gallon)[3]	20.5	20.7	20.9	20.9	21.5	21.5	21.0	21.2	21.3	22.8	22.8
New Commercial Light Truck (MPG)[1]	20.1	21.2	21.3	21.3	21.9	21.9	22.1	22.4	22.4	24.3	24.3
Stock Commercial Light Truck (MPG)[1]	14.8	15.6	15.6	15.6	15.6	15.6	16.1	16.1	16.1	16.5	16.5
Aircraft Efficiency (seat miles per gallon)	51.7	54.0	54.0	54.0	54.0	54.0	56.1	56.2	56.2	57.5	57.5
Freight Truck Efficiency (miles per gallon)	6.0	6.2	6.5	6.5	6.5	6.5	6.4	6.8	6.8	6.8	6.8
Rail Efficiency (ton miles per thousand Btu)	2.8	2.9	2.9	2.9	3.1	3.1	3.1	3.1	3.1	3.3	3.3
Domestic Shipping Efficiency (ton miles per thousand Btu)	2.3	2.5	2.5	2.5	2.5	2.5	2.7	2.7	2.7	2.7	2.7
Energy Use by Mode (quadrillion Btu)											
Light-Duty Vehicles	14.88	16.91	16.81	16.80	15.30	15.29	18.43	18.14	18.13	15.57	15.57
Commercial Light Trucks[1]	0.62	0.67	0.67	0.67	0.64	0.64	0.72	0.72	0.72	0.67	0.67
Freight Trucks[4]	4.55	5.28	5.07	5.06	5.05	5.05	5.76	5.42	5.42	5.39	5.39
Air[5]	3.50	3.93	3.94	3.94	3.91	3.91	4.55	4.56	4.56	4.46	4.45
Rail[6]	0.57	0.62	0.62	0.59	0.58	0.57	0.65	0.64	0.57	0.57	0.54
Marine[7]	1.29	1.44	1.43	1.43	1.43	1.43	1.46	1.45	1.45	1.44	1.44
Pipeline Fuel	0.66	0.82	0.79	0.81	0.77	0.80	0.90	0.85	0.95	0.85	0.91
Lubricants	0.22	0.25	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26
Total	**26.28**	**29.94**	**29.58**	**29.56**	**27.94**	**27.94**	**32.77**	**32.04**	**32.05**	**29.21**	**29.23**
Energy Use by Mode (million barrels per day oil equivalent)											
Light-Duty Vehicles	7.76	8.87	8.81	8.81	8.03	8.02	9.66	9.50	9.50	8.17	8.16
Commercial Light Trucks[1]	0.32	0.35	0.35	0.35	0.34	0.34	0.38	0.37	0.37	0.35	0.35
Freight Trucks[4]	2.03	2.37	2.27	2.27	2.26	2.26	2.59	2.43	2.43	2.42	2.42
Railroad	0.23	0.25	0.25	0.24	0.23	0.23	0.26	0.26	0.22	0.22	0.21
Domestic Shipping	0.13	0.14	0.13	0.13	0.13	0.13	0.14	0.13	0.13	0.13	0.13
International Shipping	0.30	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Air[5]	1.46	1.66	1.67	1.66	1.65	1.65	1.94	1.95	1.95	1.90	1.89
Military Use	0.28	0.29	0.29	0.29	0.29	0.29	0.32	0.32	0.32	0.32	0.32
Bus Transportation	0.09	0.09	0.09	0.09	0.08	0.08	0.09	0.08	0.08	0.08	0.08
Rail Transportation[6]	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
Recreational Boats	0.16	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.18
Lubricants	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Pipeline Fuel	0.33	0.42	0.40	0.41	0.39	0.40	0.46	0.43	0.48	0.43	0.46
Total	**13.24**	**15.11**	**14.94**	**14.93**	**14.09**	**14.09**	**16.53**	**16.17**	**16.18**	**14.71**	**14.72**

[1]Commercial trucks 8,500 to 10,000 pounds.
[2]Environmental Protection Agency rated miles per gallon.
[3]Combined car and light truck "on-the-road" estimate.
[4]Includes energy use by buses and military distillate consumption.
[5]Includes jet fuel and aviation gasoline.
[6]Includes passenger rail.
[7]Includes military residual fuel use and recreation boats.
Btu = British thermal unit.
VMT=Vehicle miles traveled.
MPG = Miles per gallon.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999: U.S. Department of Transportation, Research and Special Programs Administration, *Air Carrier Statistics Monthly, December 1999/1998* (Washington, DC, 1999); Energy Information Administration (EIA), *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf; EIA, *Fuel Oil and Kerosene Sales 1998*, DOE/EIA-0535(98) (Washington, DC, August 1999); and United States Department of Defense, Defense Fuel Supply Center. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
3331	3335	3335	3058	3059	3575	3579	3579	3315	3316
103	102	102	97	97	112	111	111	106	106
313	305	305	304	304	352	339	338	337	337
1933	1948	1949	1941	1941	2316	2340	2340	2332	2332
1840	1782	1522	1623	1525	1967	1881	1609	1693	1594
834	789	779	764	767	890	826	812	795	796
27.6	28.6	28.6	33.6	33.6	28.1	29.0	29.0	34.4	34.4
32.5	34.5	34.5	39.6	39.6	32.5	34.5	34.5	40.1	40.1
24.0	24.3	24.3	29.2	29.2	24.7	25.0	25.0	30.0	30.0
21.3	21.7	21.7	24.4	24.4	21.5	22.1	22.1	25.8	25.8
22.8	23.2	23.2	26.5	26.5	23.4	23.9	23.9	27.4	27.4
16.6	16.7	16.7	17.6	17.6	17.0	17.2	17.2	18.7	18.7
58.2	59.0	58.9	61.8	61.8	60.3	62.5	62.3	65.4	65.4
6.7	7.1	7.1	7.2	7.2	6.9	7.4	7.4	7.6	7.6
3.3	3.3	3.3	3.6	3.6	3.4	3.5	3.5	3.9	3.9
2.8	2.8	2.8	2.8	2.8	3.0	3.0	3.0	3.0	3.0
19.76	19.26	19.26	15.71	15.71	20.92	20.20	20.20	15.97	15.98
0.77	0.76	0.76	0.69	0.69	0.83	0.81	0.81	0.71	0.71
6.23	5.73	5.73	5.63	5.63	6.73	6.06	6.06	5.88	5.88
5.28	5.25	5.26	5.03	5.02	6.04	5.91	5.92	5.66	5.66
0.67	0.65	0.57	0.56	0.54	0.69	0.65	0.58	0.56	0.53
1.49	1.46	1.46	1.45	1.46	1.52	1.48	1.47	1.47	1.47
1.01	0.91	0.99	0.88	0.94	1.10	0.96	1.03	0.94	0.98
0.29	0.29	0.29	0.29	0.29	0.31	0.31	0.31	0.31	0.31
35.53	**34.30**	**34.31**	**30.24**	**30.26**	**38.16**	**36.34**	**36.34**	**31.48**	**31.50**
10.35	10.09	10.09	8.24	8.24	10.95	10.59	10.58	8.37	8.37
0.41	0.40	0.40	0.36	0.36	0.43	0.42	0.42	0.37	0.37
2.81	2.58	2.58	2.54	2.54	3.04	2.74	2.73	2.66	2.66
0.27	0.26	0.22	0.21	0.20	0.27	0.25	0.22	0.20	0.19
0.14	0.13	0.13	0.12	0.13	0.14	0.13	0.12	0.12	0.12
0.36	0.35	0.35	0.35	0.35	0.36	0.35	0.35	0.35	0.35
2.28	2.26	2.27	2.15	2.15	2.63	2.56	2.57	2.44	2.44
0.34	0.34	0.34	0.34	0.34	0.36	0.36	0.36	0.36	0.36
0.09	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.08
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
0.19	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.19	0.19
0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15
0.51	0.46	0.50	0.45	0.48	0.55	0.48	0.52	0.47	0.50
17.90	**17.32**	**17.33**	**15.22**	**15.23**	**19.22**	**18.36**	**18.36**	**15.83**	**15.84**

Table D8. Electricity Supply, Disposition, Prices, and Emissions
(Billion Kilowatthours, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Generation by Fuel Type											
Electric Generators[1]											
Coal	1830	2105	2079	1777	1910	1735	2238	2221	1357	1737	1395
Petroleum	85	42	31	12	17	12	25	21	11	12	10
Natural Gas[2]	370	582	509	686	525	671	826	616	1138	800	1090
Nuclear Power	730	740	740	740	740	740	720	720	741	735	735
Pumped Storage	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Renewable Sources[3]	355	372	384	454	471	485	396	406	543	555	578
Total	**3369**	**3839**	**3742**	**3669**	**3662**	**3642**	**4204**	**3983**	**3788**	**3838**	**3807**
Nonutility Generation for Own Use	16	17	17	23	21	21	17	16	22	21	19
Distributed Generation	0	0	0	0	0	0	1	1	0	1	0
Cogenerators[4]											
Coal	47	53	53	52	52	52	51	51	46	48	44
Petroleum	9	10	10	10	10	10	10	10	10	10	10
Natural Gas	206	236	236	245	239	239	259	256	303	267	269
Other Gaseous Fuels[5]	4	6	6	6	6	6	7	7	7	6	6
Renewable Sources[3]	31	34	34	34	35	35	39	39	39	42	42
Other[6]	5	5	5	5	5	5	5	5	5	5	5
Total	**303**	**344**	**344**	**352**	**347**	**347**	**372**	**368**	**410**	**379**	**376**
Other End-Use Generators[7]	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Sales to Utilities	151	172	171	171	171	171	179	179	181	178	173
Generation for Own Use	156	177	177	186	181	181	197	193	234	206	208
Net Imports[8]	**33**	**57**	**57**	**59**	**57**	**57**	**35**	**35**	**49**	**35**	**35**
Electricity Sales by Sector											
Residential	1145	1337	1313	1280	1271	1265	1438	1359	1290	1286	1273
Commercial	1073	1291	1235	1212	1222	1215	1442	1336	1289	1323	1309
Industrial	1058	1137	1124	1109	1100	1096	1219	1195	1138	1139	1134
Transportation	17	26	25	25	25	25	34	30	30	29	29
Total	**3294**	**3790**	**3697**	**3625**	**3618**	**3600**	**4133**	**3920**	**3747**	**3777**	**3745**
End-Use Prices (1999 cents per kwh)[9]											
Residential	8.1	7.6	7.4	8.0	7.9	8.1	7.6	7.3	8.5	8.0	8.2
Commercial	7.4	6.9	6.7	7.4	7.4	7.6	6.4	6.0	7.4	6.7	7.0
Industrial	4.5	4.4	4.2	4.8	4.8	5.0	4.1	3.8	5.1	4.5	4.8
Transportation	5.3	5.0	4.9	5.4	5.3	5.4	4.7	4.5	5.7	5.2	5.5
All Sectors Average	**6.7**	**6.4**	**6.2**	**6.8**	**6.8**	**6.9**	**6.1**	**5.8**	**7.1**	**6.5**	**6.7**
Prices by Service Category[9] (1999 cents per kilowatthour)											
Generation	4.1	3.8	3.6	4.2	4.2	4.3	3.4	3.1	4.2	3.7	3.9
Transmission	0.6	0.6	0.6	0.7	0.6	0.7	0.7	0.7	0.8	0.7	0.8
Distribution	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1
Emissions (million short tons)											
Sulfur Dioxide	13.49	10.39	10.39	6.34	10.39	6.34	9.70	9.70	2.99	9.70	2.99
Nitrogen Oxide	5.43	4.30	4.21	2.66	3.87	2.64	4.34	4.20	1.74	3.52	1.78

[1]Includes grid-connected generation at all utilities and nonutilities except for cogenerators. Includes small power producers and exempt wholesale generators.
[2]Includes electricity generation by fuel cells.
[3]Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar, and wind power.
[4]Cogenerators produce electricity and other useful thermal energy. Includes sales to utilities and generation for own use.
[5]Other gaseous fuels include refinery and still gas.
[6]Other includes hydrogen, sulfur, batteries, chemicals, fish oil, and spent sulfite liquor.
[7]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.
[8]In 1999 approximately 70 percent of the U.S. electricity imports were provided by renewable sources (hydroelectricity); EIA does not project future proportions for the fuel source of imported electricity.
[9]Prices represent average revenue per kilowatthour.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
2279	2269	1307	1677	1339	2302	2296	1284	1567	1276
24	22	11	11	10	23	21	11	10	9
1168	771	1271	964	1260	1488	908	1330	1181	1416
653	653	706	664	675	610	595	646	575	617
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
400	409	550	558	575	399	413	624	551	561
4524	**4123**	**3845**	**3873**	**3857**	**4821**	**4231**	**3893**	**3883**	**3878**
17	16	21	21	19	16	16	21	20	19
3	1	0	1	0	5	2	0	1	0
52	51	46	47	44	52	51	42	43	41
10	10	10	10	10	10	10	10	10	10
287	282	385	301	300	317	322	494	349	343
8	7	8	7	7	8	8	9	7	7
44	43	43	49	49	48	47	46	56	56
5	5	5	5	5	6	5	6	5	5
406	**400**	**497**	**419**	**414**	**440**	**443**	**607**	**470**	**463**
5	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
193	192	206	193	189	208	209	239	210	206
218	212	296	232	231	237	239	373	265	261
22	**22**	**34**	**22**	**22**	**23**	**23**	**35**	**23**	**23**
1545	1372	1293	1243	1235	1668	1404	1328	1227	1224
1567	1399	1339	1367	1359	1653	1421	1355	1370	1365
1298	1260	1156	1180	1179	1394	1331	1185	1224	1227
43	36	36	34	34	49	42	41	40	40
4453	**4066**	**3824**	**3824**	**3807**	**4763**	**4197**	**3910**	**3862**	**3855**
7.6	7.6	8.7	8.1	8.2	7.6	7.6	8.6	8.2	8.2
6.4	6.2	7.6	6.8	6.9	6.4	6.3	7.5	6.9	6.9
4.1	3.9	5.4	4.5	4.7	4.1	4.0	5.3	4.6	4.7
4.6	4.6	5.8	5.3	5.4	4.5	4.5	5.6	5.3	5.2
6.1	**5.9**	**7.3**	**6.5**	**6.6**	**6.1**	**6.0**	**7.2**	**6.6**	**6.6**
3.4	3.2	4.5	3.7	3.8	3.5	3.3	4.4	3.8	3.8
0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.7	0.7
2.0	2.1	2.1	2.1	2.1	2.0	2.1	2.1	2.1	2.1
8.95	8.95	2.64	6.70	2.64	8.95	8.95	2.24	4.48	2.24
4.44	4.28	1.70	3.41	1.71	4.48	4.33	1.67	3.18	1.64

Table D9. Electricity Generating Capability
(Gigawatts)

Net Summer Capability[1]	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Electric Generators[2]											
Capability											
Coal Steam	305.1	303.9	303.9	302.8	302.8	302.8	317.8	321.5	258.6	280.7	258.1
Other Fossil Steam[3]	137.4	124.9	125.4	113.8	114.6	105.3	117.4	117.0	102.9	100.3	90.0
Combined Cycle	21.0	52.4	51.8	92.4	64.0	87.2	107.3	72.2	151.2	102.6	147.7
Combustion Turbine/Diesel	86.8	126.4	123.4	129.1	116.4	113.3	149.8	138.2	134.5	125.9	123.5
Nuclear Power	97.4	97.5	97.5	97.5	97.5	97.5	93.7	93.7	96.9	96.1	96.1
Pumped Storage	19.3	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Renewable Sources[4]	88.8	94.7	96.5	100.6	105.6	107.7	97.9	99.8	119.6	126.1	131.5
Distributed Generation[5]	0.0	0.8	0.6	0.2	0.6	0.1	2.5	1.6	0.5	1.4	0.4
Total	**755.9**	**820.0**	**818.6**	**855.9**	**820.9**	**833.4**	**906.0**	**863.7**	**883.8**	**852.6**	**867.1**
Cumulative Planned Additions[6]											
Coal Steam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Fossil Steam[3]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Combined Cycle	0.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
Combustion Turbine/Diesel	0.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Renewable Sources[4]	0.0	5.1	5.1	5.1	5.1	5.1	6.7	6.7	6.7	6.7	6.7
Distributed Generation[5]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.0**	**32.0**	**32.0**	**32.0**	**32.0**	**32.0**	**33.7**	**33.7**	**33.7**	**33.7**	**33.7**
Cumulative Unplanned Additions[6]											
Coal Steam	0.0	1.1	1.1	0.0	0.0	0.0	18.2	22.0	0.0	0.5	0.0
Other Fossil Steam[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combined Cycle	0.0	18.6	18.0	58.6	30.2	53.4	73.6	38.6	117.5	68.9	114.1
Combustion Turbine/Diesel	0.0	30.9	28.0	23.0	24.6	14.3	55.4	43.7	29.5	35.9	25.2
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Sources[4]	0.0	0.4	2.1	6.3	11.3	13.4	1.9	3.8	23.6	30.1	35.6
Distributed Generation[5]	0.0	0.8	0.6	0.2	0.6	0.1	2.5	1.6	0.5	1.4	0.4
Total	**0.0**	**51.7**	**49.9**	**88.1**	**66.7**	**81.2**	**151.5**	**109.7**	**171.1**	**136.7**	**175.2**
Cumulative Total Additions	**0.0**	**83.7**	**81.9**	**120.1**	**98.7**	**113.2**	**185.2**	**143.4**	**204.8**	**170.4**	**208.9**
Cumulative Retirements[7]											
Coal Steam	0.0	2.3	2.3	2.3	2.3	2.3	5.5	5.6	46.5	25.0	47.0
Other Fossil Steam[3]	0.0	12.7	12.2	23.8	23.0	32.3	20.2	20.6	34.8	37.4	47.6
Combined Cycle	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.1	0.1
Combustion Turbine/Diesel	0.0	5.5	5.5	4.9	6.2	9.0	6.6	6.4	6.0	8.0	9.6
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	0.6	1.4	1.4
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Sources[4]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**0.0**	**20.6**	**20.2**	**31.2**	**31.7**	**43.8**	**36.4**	**36.8**	**88.1**	**71.9**	**105.9**

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF Advanced	CEF Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF Advanced	CEF Advanced with Emissions Limits
317.9	325.2	246.1	277.1	250.4	317.3	325.4	240.6	270.2	239.2
116.4	115.8	98.7	98.8	87.8	114.9	112.6	94.0	90.5	79.1
152.6	89.7	165.7	122.7	166.2	199.0	105.5	173.4	149.5	186.8
174.4	144.6	136.1	127.6	129.6	197.4	154.6	136.9	128.6	129.9
81.5	81.5	90.1	82.8	84.3	76.3	74.4	81.9	70.3	76.9
19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
98.9	100.9	122.5	127.7	132.6	99.4	102.0	142.9	128.1	133.0
5.8	2.5	0.8	1.5	0.7	11.0	3.9	1.0	1.6	0.8
967.2	**879.8**	**879.8**	**858.0**	**871.3**	**1035.1**	**898.2**	**890.5**	**858.6**	**865.4**
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
7.7	7.7	7.7	7.7	7.7	8.1	8.1	8.1	8.1	8.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34.8	**34.8**	**34.8**	**34.8**	**34.8**	**35.3**	**35.3**	**35.3**	**35.3**	**35.3**
18.8	26.2	0.0	0.5	0.0	19.5	27.7	0.0	0.5	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
119.0	56.1	132.5	89.0	132.8	165.4	71.9	140.2	116.1	153.5
80.1	51.2	31.2	38.0	31.3	103.1	61.2	31.9	39.0	31.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.9	3.8	25.5	30.7	35.6	1.9	4.5	45.4	30.7	35.6
5.8	2.5	0.8	1.5	0.7	11.0	3.9	1.0	1.6	0.8
225.5	**139.8**	**190.0**	**159.7**	**200.4**	**300.8**	**169.2**	**218.6**	**188.0**	**221.5**
260.4	**174.6**	**224.9**	**194.6**	**235.2**	**336.1**	**204.5**	**253.9**	**223.3**	**256.8**
6.0	6.2	59.1	28.6	54.7	7.3	7.4	64.5	35.4	66.0
21.2	21.8	38.9	38.9	49.8	22.7	25.0	43.6	47.1	58.5
0.2	0.2	0.6	0.1	0.5	0.2	0.2	0.6	0.5	0.5
6.7	7.5	6.1	8.4	9.7	6.7	7.5	6.1	8.4	9.7
16.0	16.0	7.3	14.7	13.1	21.2	23.1	15.6	27.2	20.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
50.3	**51.8**	**112.1**	**90.7**	**128.0**	**58.1**	**63.3**	**130.5**	**118.7**	**155.5**

Table D9. Electricity Generating Capability (Continued)
(Gigawatts)

Net Summer Capability[1]	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Cogenerators[8]											
Capability											
Coal	8.4	8.9	8.9	8.9	8.9	8.9	8.6	8.5	7.6	7.7	7.3
Petroleum	2.7	2.9	2.9	2.9	2.8	2.8	2.9	2.9	2.9	2.9	2.9
Natural Gas	34.6	39.7	39.8	41.1	40.3	40.3	43.1	42.6	49.2	44.4	44.8
Other Gaseous Fuels	0.2	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.8	0.8
Renewable Sources[4]	5.4	5.9	5.9	5.8	6.0	6.0	6.8	6.7	6.7	7.3	7.3
Other	1.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total	**52.4**	**59.1**	**59.1**	**60.4**	**59.7**	**59.7**	**63.1**	**62.4**	**68.2**	**63.9**	**63.9**
Cumulative Additions[6]	**0.0**	**6.7**	**6.7**	**8.0**	**7.3**	**7.3**	**10.7**	**10.0**	**15.8**	**11.5**	**11.4**
Other End-Use Generators[9]											
Renewable Sources[10]	1.0	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3	1.3
Cumulative Additions	0.0	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3

[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.
[2]Includes grid-connected utilities and nonutilities except for cogenerators. Includes small power producers and exempt wholesale generators.
[3]Includes oil-, gas-, and dual-fired capability.
[4]Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar and wind power.
[5]Primarily peak-load capacity fueled by natural gas
[6]Cumulative additions after December 31, 1999.
[7]Cumulative total retirements after December 31, 1999.
[8]Nameplate capacity is reported for nonutilities on Form EIA-860B, "Annual Electric Generator Report - Nonutility." Nameplate capacity is designated by the manufacturer. The nameplate capacity has been converted to the net summer capability based on historic relationships.
[9]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. Excludes off-grid photovoltaics and other generators not connected to the distribution or transmission systems.
[10]See Table D17 for more detail.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model estimates and may differ slightly from official EIA data reports. Net summer capability has been estimated for nonutility generators to be consistent with capability for electric utility generators.
Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF Advanced	CEF Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF Advanced	CEF Advanced with Emissions Limits
8.6	8.5	7.5	7.7	7.3	8.6	8.5	7.5	7.1	7.1
2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.0	2.9	2.9
46.9	46.2	60.3	49.0	48.9	51.2	51.6	75.2	55.5	54.9
1.0	1.0	1.1	0.9	0.9	1.1	1.0	1.2	0.9	0.9
7.6	7.4	7.4	8.5	8.5	8.3	8.1	8.1	9.7	9.7
0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
67.9	**66.8**	**80.1**	**69.8**	**69.3**	**73.0**	**73.0**	**95.8**	**77.0**	**76.3**
15.5	**14.4**	**27.7**	**17.3**	**16.9**	**20.5**	**20.6**	**43.3**	**24.6**	**23.9**
1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table D10. Electricity Trade
(Billion Kilowatthours, Unless Otherwise Noted)

Electricity Trade	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Interregional Electricity Trade											
Gross Domestic Firm Power Trade	182.2	125.3	125.3	125.3	125.3	125.3	102.9	102.9	102.9	102.9	102.9
Gross Domestic Economy Trade	152.1	199.1	204.3	144.1	141.2	129.2	154.6	165.7	95.2	111.2	98.3
Gross Domestic Trade	**334.3**	**324.4**	**329.6**	**269.4**	**266.5**	**254.4**	**257.5**	**268.6**	**198.1**	**214.2**	**201.2**
Gross Domestic Firm Power Sales (million 1999 dollars)	8588.1	5905.8	5905.8	5905.8	5905.8	5905.8	4851.2	4851.2	4851.2	4851.2	4851.2
Gross Domestic Economy Sales (million 1999 dollars)	4204.3	6352.8	6072.6	5400.5	5164.1	4980.0	4407.4	4386.1	3794.4	3712.1	3612.1
Gross Domestic Sales (million 1999 dollars)	**12792.4**	**12258.6**	**11978.4**	**11306.3**	**11069.9**	**10885.8**	**9258.7**	**9237.3**	**8645.6**	**8563.3**	**8463.3**
International Electricity Trade											
Firm Power Imports From Canada & Mexico[1]	27.0	10.7	10.7	11.8	10.7	10.7	5.8	5.8	19.1	5.8	5.8
Economy Imports From Canada & Mexico[1]	21.9	63.5	63.5	63.5	63.5	63.5	45.9	45.9	45.9	45.9	45.9
Gross Imports From Canada and Mexico[1]	**48.9**	**74.1**	**74.1**	**75.3**	**74.1**	**74.1**	**51.7**	**51.7**	**65.0**	**51.7**	**51.7**
Firm Power Exports To Canada and Mexico	9.2	9.7	9.7	9.7	9.7	9.7	8.7	8.7	8.7	8.7	8.7
Economy Exports To Canada and Mexico	6.3	7.0	7.0	7.0	7.0	7.0	7.7	7.7	7.7	7.7	7.7
Gross Exports To Canada and Mexico	**15.5**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**	**16.4**	**16.4**	**16.4**	**16.4**	**16.4**

[1]Historically electricity imports were primarily from renewable resources, principally hydroelectric.

CEF = Clean Energy Future.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports. Firm Power Sales are capacity sales, meaning the delivery of the power is scheduled as part of the normal operating conditions of the affected electric systems. Economy Sales are subject to curtailment or cessation of delivery by the supplier in accordance with prior agreements or under specified conditions.

Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
45.7	45.7	45.7	45.7	45.7	0.0	0.0	0.0	0.0	0.0
154.5	160.2	89.8	102.3	92.5	146.4	160.4	104.5	110.6	95.6
200.2	**205.9**	**135.5**	**148.0**	**138.2**	**146.4**	**160.4**	**104.5**	**110.6**	**95.6**
2156.1	2156.1	2156.1	2156.1	2156.1	0.0	0.0	0.0	0.0	0.0
4560.7	4350.8	3814.3	3467.5	3313.5	4448.7	4345.2	4179.3	3734.3	3344.9
6716.8	**6506.9**	**5970.4**	**5623.6**	**5469.6**	**4448.7**	**4345.2**	**4179.3**	**3734.3**	**3344.9**
2.6	2.6	14.7	2.6	2.6	0.0	0.0	12.1	0.0	0.0
30.8	30.8	30.8	30.8	30.8	30.6	30.6	30.6	30.6	30.6
33.4	**33.4**	**45.6**	**33.4**	**33.4**	**30.6**	**30.6**	**42.7**	**30.6**	**30.6**
3.9	3.9	3.9	3.9	3.9	0.0	0.0	0.0	0.0	0.0
7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
11.5	**11.5**	**11.5**	**11.5**	**11.5**	**7.7**	**7.7**	**7.7**	**7.7**	**7.7**

Table D11. Petroleum Supply and Disposition Balance
(Million Barrels per Day, Unless Otherwise Noted)

Supply and Disposition	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Crude Oil											
Domestic Crude Production[1]	5.88	5.69	5.67	5.68	5.68	5.68	5.30	5.28	5.27	5.23	5.26
Alaska	1.05	0.79	0.79	0.79	0.79	0.79	0.65	0.65	0.65	0.65	0.65
Lower 48 States	4.83	4.90	4.88	4.89	4.89	4.89	4.66	4.63	4.62	4.58	4.62
Net Imports	8.61	9.80	9.81	9.80	9.69	9.69	10.31	10.34	10.39	10.27	10.22
Gross Imports	8.73	9.87	9.87	9.86	9.75	9.75	10.36	10.39	10.44	10.31	10.27
Exports	0.12	0.07	0.06	0.07	0.07	0.07	0.05	0.05	0.05	0.05	0.05
Other Crude Supply[2]	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Crude Supply	**14.80**	**15.49**	**15.48**	**15.48**	**15.37**	**15.37**	**15.61**	**15.62**	**15.66**	**15.49**	**15.49**
Natural Gas Plant Liquids	**1.85**	**2.19**	**2.10**	**2.17**	**2.06**	**2.13**	**2.37**	**2.21**	**2.45**	**2.22**	**2.34**
Other Inputs[3]	**0.60**	**0.19**	**0.30**	**0.30**	**0.26**	**0.29**	**0.20**	**0.30**	**0.21**	**0.29**	**0.20**
Refinery Processing Gain[4]	**0.89**	**0.93**	**0.91**	**0.89**	**0.91**	**0.89**	**0.99**	**0.94**	**0.94**	**0.90**	**0.91**
Net Product Imports[5]	**1.30**	**2.25**	**1.98**	**1.82**	**1.13**	**1.02**	**3.44**	**2.96**	**2.73**	**1.47**	**1.44**
Gross Refined Product Imports[6]	1.73	2.45	2.35	2.23	1.58	1.48	3.43	3.03	2.87	1.83	1.82
Unfinished Oil Imports	0.32	0.56	0.40	0.37	0.32	0.32	0.79	0.72	0.64	0.38	0.36
Ether Imports	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.82	0.76	0.78	0.78	0.77	0.78	0.78	0.78	0.78	0.75	0.74
Total Primary Supply[7]	**19.44**	**21.05**	**20.77**	**20.66**	**19.72**	**19.70**	**22.61**	**22.04**	**21.99**	**20.37**	**20.38**
Refined Petroleum Products Supplied											
Motor Gasoline[8]	8.43	9.37	9.29	9.29	8.53	8.52	10.06	9.85	9.84	8.57	8.57
Jet Fuel[9]	1.67	1.88	1.88	1.88	1.87	1.87	2.17	2.18	2.19	2.13	2.13
Distillate Fuel[10]	3.54	4.12	4.03	3.99	3.92	3.91	4.48	4.32	4.27	4.13	4.12
Residual Fuel	0.74	0.64	0.59	0.52	0.53	0.51	0.61	0.58	0.56	0.54	0.54
Other[11]	5.07	5.09	5.02	5.03	4.93	4.95	5.33	5.16	5.19	5.05	5.07
Total	**19.46**	**21.10**	**20.82**	**20.71**	**19.78**	**19.76**	**22.64**	**22.09**	**22.04**	**20.43**	**20.43**
Refined Petroleum Products Supplied											
Residential and Commercial	1.10	1.10	1.10	1.10	1.06	1.06	1.05	1.04	1.05	0.99	1.00
Industrial[12]	5.19	5.22	5.15	5.15	5.06	5.07	5.56	5.37	5.40	5.25	5.28
Transportation	12.86	14.58	14.43	14.40	13.59	13.57	15.92	15.58	15.55	14.14	14.12
Electric Generators[13]	0.31	0.19	0.14	0.05	0.07	0.05	0.11	0.09	0.04	0.05	0.04
Total	**19.46**	**21.10**	**20.82**	**20.71**	**19.78**	**19.76**	**22.64**	**22.09**	**22.04**	**20.43**	**20.43**
Discrepancy[14]	**-0.02**	**-0.05**	**-0.05**	**-0.05**	**-0.06**	**-0.06**	**-0.04**	**-0.05**	**-0.05**	**-0.06**	**-0.05**
World Oil Price (1999 dollars per barrel)[15]	**17.22**	**20.83**	**20.83**	**20.83**	**20.83**	**20.83**	**21.37**	**21.37**	**21.37**	**21.37**	**21.37**
Import Share of Product Supplied	**0.51**	**0.57**	**0.57**	**0.56**	**0.55**	**0.54**	**0.61**	**0.60**	**0.60**	**0.57**	**0.57**
Net Expenditures for Imported Crude Oil and Petroleum Products (billion 1999 dollars)	**59.74**	**94.30**	**92.14**	**90.82**	**82.64**	**81.80**	**112.23**	**108.55**	**106.91**	**92.56**	**91.93**
Domestic Refinery Distillation Capacity[16]	**16.5**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**	**16.7**
Capacity Utilization Rate (percent)	**93.0**	**92.6**	**92.7**	**92.6**	**92.0**	**92.1**	**93.3**	**93.5**	**93.7**	**92.8**	**92.7**

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude stock withdrawals minus crude products supplied.
[3]Includes alcohols, ethers, petroleum product stock withdrawals, domestic sources of blending components, and other hydrocarbons.
[4]Represents volumetric gain in refinery distillation and cracking processes.
[5]Includes net imports of finished petroleum products, unfinished oils, other hydrocarbons, alcohols, ethers, and blending components.
[6]Includes blending components.
[7]Total crude supply plus natural gas plant liquids, other inputs, refinery processing gain, and net petroleum imports.
[8]Includes ethanol and ethers blended into gasoline.
[9]Includes naphtha and kerosene types.
[10]Includes distillate and kerosene.
[11]Includes aviation gasoline, liquefied petroleum gas, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, and miscellaneous petroleum products.
[12]Includes consumption by cogenerators.
[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]Balancing item. Includes unaccounted for supply, losses and gains.
[15]Average refiner acquisition cost for imported crude oil.
[16]End-of-year capacity.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 product supplied data from Table D2. Other 1999 data: Energy Information Administration (EIA), *Petroleum Supply Annual 1999,* DOE/EIA-0340(99/1) (Washington, DC, June 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
5.23	5.15	5.22	5.08	5.18	5.22	5.07	5.17	5.06	5.11
0.70	0.70	0.70	0.70	0.70	0.64	0.64	0.64	0.64	0.64
4.53	4.44	4.52	4.38	4.48	4.58	4.43	4.54	4.42	4.47
11.59	11.39	11.29	10.67	10.57	11.89	12.07	11.89	11.07	11.07
11.64	11.43	11.33	10.71	10.61	11.93	12.11	11.93	11.11	11.11
0.05	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.04	0.04
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.82	**16.53**	**16.51**	**15.75**	**15.75**	**17.11**	**17.15**	**17.06**	**16.13**	**16.17**
2.65	**2.38**	**2.59**	**2.33**	**2.45**	**2.92**	**2.53**	**2.72**	**2.48**	**2.58**
0.21	**0.39**	**0.34**	**0.35**	**0.31**	**0.22**	**0.66**	**0.63**	**0.58**	**0.48**
0.96	**0.92**	**0.92**	**0.90**	**0.90**	**0.98**	**0.91**	**0.90**	**0.89**	**0.91**
3.51	**3.05**	**2.88**	**1.58**	**1.52**	**4.46**	**3.16**	**3.11**	**1.51**	**1.46**
3.51	3.27	3.17	1.95	1.91	4.40	3.45	3.43	1.92	1.87
0.78	0.55	0.48	0.39	0.38	0.89	0.52	0.51	0.42	0.42
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.79	0.77	0.77	0.76	0.77	0.83	0.82	0.83	0.83	0.83
24.14	**23.26**	**23.25**	**20.91**	**20.93**	**25.69**	**24.41**	**24.43**	**21.59**	**21.60**
10.70	10.34	10.34	8.58	8.57	11.29	10.78	10.77	8.66	8.66
2.52	2.52	2.53	2.41	2.41	2.88	2.85	2.86	2.73	2.73
4.80	4.57	4.52	4.29	4.28	5.12	4.79	4.74	4.44	4.43
0.61	0.59	0.56	0.54	0.54	0.61	0.60	0.57	0.54	0.53
5.55	5.28	5.34	5.14	5.18	5.82	5.45	5.52	5.28	5.30
24.18	**23.31**	**23.29**	**20.96**	**20.98**	**25.73**	**24.46**	**24.46**	**21.64**	**21.65**
1.03	1.01	1.03	0.95	0.95	1.01	0.99	1.02	0.92	0.93
5.83	5.55	5.59	5.39	5.42	6.15	5.75	5.82	5.54	5.56
17.21	16.65	16.62	14.58	14.57	18.46	17.62	17.59	15.14	15.13
0.11	0.10	0.04	0.05	0.04	0.10	0.09	0.04	0.04	0.04
24.18	**23.31**	**23.29**	**20.96**	**20.98**	**25.73**	**24.46**	**24.46**	**21.64**	**21.65**
-0.04	**-0.05**	**-0.04**	**-0.05**	**-0.05**	**-0.04**	**-0.04**	**-0.04**	**-0.05**	**-0.04**
21.89	**21.89**	**21.89**	**21.89**	**21.89**	**22.41**	**22.41**	**22.41**	**22.41**	**22.41**
0.62	**0.62**	**0.61**	**0.58**	**0.58**	**0.64**	**0.62**	**0.61**	**0.58**	**0.58**
128.03	**120.87**	**118.43**	**98.53**	**97.20**	**143.48**	**130.13**	**128.10**	**103.05**	**102.53**
17.9	**17.5**	**17.5**	**16.9**	**16.9**	**18.1**	**18.1**	**18.0**	**17.1**	**17.1**
94.0	**94.5**	**94.5**	**93.2**	**93.4**	**94.7**	**95.1**	**95.0**	**94.6**	**94.6**

Table D12. Petroleum Product Prices
(1999 Cents per Gallon, Unless Otherwise Noted)

Sector and Fuel	1999	Projections									
		2005					2010				
		Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
World Oil Price (1999 dollars per barrel)	**17.22**	**20.83**	**20.83**	**20.83**	**20.83**	**20.83**	**21.37**	**21.37**	**21.37**	**21.37**	**21.37**
Delivered Sector Product Prices											
Residential											
Distillate Fuel	87.0	102.3	101.8	101.0	99.5	99.4	105.0	104.9	103.9	101.4	101.6
Liquefied Petroleum Gas	89.4	108.9	108.8	108.5	108.7	108.1	110.6	110.8	109.5	103.9	107.6
Commercial											
Distillate Fuel	60.6	71.7	71.2	70.4	68.8	68.7	74.2	74.1	73.0	70.6	70.7
Residual Fuel	39.3	54.5	54.2	53.8	53.9	53.8	55.5	55.1	54.9	55.0	54.9
Residual Fuel (1999 dollars per barrel)	16.53	22.91	22.75	22.59	22.66	22.61	23.29	23.13	23.05	23.09	23.08
Industrial[1]											
Distillate Fuel	64.5	73.9	73.5	72.8	71.3	71.3	76.8	76.5	75.5	73.2	73.5
Liquefied Petroleum Gas	73.4	66.9	66.7	66.7	66.3	66.0	67.0	66.9	65.7	59.9	64.1
Residual Fuel	41.7	50.5	50.3	50.0	50.2	50.1	51.4	51.3	51.1	51.2	51.3
Residual Fuel (1999 dollars per barrel)	17.50	21.22	21.14	20.99	21.07	21.02	21.58	21.53	21.48	21.51	21.53
Transportation											
Diesel Fuel (distillate)[2]	114.0	123.3	123.2	122.6	120.6	120.6	124.0	124.9	124.5	121.4	121.8
Jet Fuel[3]	63.5	70.5	70.4	69.9	68.2	68.2	74.1	74.2	74.0	70.1	70.5
Motor Gasoline[4]	118.2	134.0	133.4	133.5	125.4	125.4	139.6	139.4	139.8	126.3	126.3
Liquified Petroleum Gas	111.1	121.4	121.2	121.0	120.7	120.3	120.8	121.0	119.9	114.6	117.7
Residual Fuel	36.8	46.5	46.9	46.8	46.9	46.9	47.6	48.6	48.6	48.7	48.7
Residual Fuel (1999 dollars per barrel)	15.45	19.54	19.71	19.65	19.70	19.69	19.99	20.42	20.41	20.47	20.47
Ethanol (E85)	129.2	171.9	171.6	171.6	169.7	170.0	171.2	170.7	171.1	167.8	168.2
Methanol (M85)	76.2	96.3	95.1	95.4	94.6	93.6	101.2	101.1	101.2	99.2	99.7
Electric Generators[5]											
Distillate Fuel	56.4	64.6	64.3	65.8	64.1	64.5	67.3	67.3	67.9	66.3	67.4
Residual Fuel	35.8	51.3	52.3	57.8	54.8	58.3	55.4	56.1	61.2	60.4	61.9
Residual Fuel (1999 dollars per barrel)	15.03	21.56	21.98	24.29	23.02	24.49	23.26	23.56	25.71	25.38	25.98
Refined Petroleum Product Prices[6]											
Distillate Fuel	100.5	111.8	111.4	110.9	109.1	109.1	113.7	114.1	113.6	110.8	111.1
Jet Fuel[3]	63.5	70.5	70.4	69.9	68.2	68.2	74.1	74.2	74.0	70.1	70.5
Liquefied Petroleum Gas	76.3	74.7	74.6	74.5	74.2	73.8	74.7	74.8	73.7	67.8	71.9
Motor Gasoline[4]	118.2	134.0	133.3	133.5	125.4	125.4	139.6	139.4	139.8	126.3	126.3
Residual Fuel	37.0	48.7	48.9	48.6	48.7	48.7	49.9	50.4	50.4	50.5	50.5
Residual Fuel (1999 dollars per barrel)	15.54	20.44	20.52	20.43	20.47	20.45	20.96	21.18	21.16	21.21	21.21
Average	**97.8**	**110.7**	**110.4**	**110.5**	**105.1**	**105.1**	**114.5**	**114.5**	**114.5**	**104.9**	**105.5**

[1]Includes cogenerators. Includes Federal and State taxes while excluding county and state taxes.
[2] Low sulfur diesel fuel. Includes Federal and State taxes while excluding county and local taxes.
[3]Kerosene-type jet fuel.
[4]Sales weighted-average price for all grades. Includes Federal and State taxes while excluding county and local taxes.
[5]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[6]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 1999 are model results and may differ slightly from official EIA data reports.
CEF = Clean Energy Future.
Sources: 1999 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 (99/03-2000/04) (Washington, DC, 1999-2000). 1999 prices for all other petroleum products are derived from EIA, *State Energy Price and Expenditure Report 1997*, DOE/EIA-0376(97) (Washington, DC, July 2000). **Projections**: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
21.89	**21.89**	**21.89**	**21.89**	**21.89**	**22.41**	**22.41**	**22.41**	**22.41**	**22.41**
104.6	103.5	102.9	103.5	103.6	107.6	105.2	104.8	104.1	103.7
110.8	112.3	107.6	107.8	106.8	109.7	111.9	108.1	102.8	104.7
73.5	72.7	71.9	72.5	72.6	76.5	74.3	73.7	73.2	72.7
56.6	56.1	55.9	56.0	56.0	57.7	57.1	56.9	57.0	57.0
23.77	23.57	23.48	23.51	23.50	24.23	23.99	23.91	23.96	23.95
76.1	75.3	74.7	75.3	75.4	79.2	77.1	76.8	76.0	75.6
67.2	68.0	63.6	63.3	63.0	66.3	67.3	64.2	57.9	60.1
52.5	52.4	52.3	52.5	52.4	53.7	53.6	53.5	53.5	53.5
22.06	22.02	21.96	22.03	22.03	22.54	22.49	22.46	22.48	22.48
123.1	122.4	121.4	121.9	121.9	122.4	121.7	121.1	119.5	119.4
74.8	73.6	73.0	71.7	71.6	77.2	75.7	75.4	73.2	73.3
133.4	132.2	132.1	124.8	124.7	132.0	130.9	130.9	122.3	122.2
120.3	121.5	117.4	117.2	116.2	117.8	119.8	116.8	111.4	113.0
48.7	50.4	50.3	50.6	50.6	49.8	52.1	52.1	52.2	52.2
20.47	21.16	21.15	21.24	21.24	20.93	21.88	21.87	21.94	21.94
172.5	159.2	159.2	151.9	151.9	173.1	146.0	146.1	139.9	140.2
103.9	104.8	104.8	103.7	101.9	105.3	105.4	105.5	103.7	101.8
67.0	66.4	68.1	68.7	69.6	70.1	68.0	71.1	70.2	71.0
56.7	57.5	63.0	63.1	64.4	58.7	59.5	64.8	65.7	66.5
23.80	24.13	26.48	26.49	27.07	24.66	25.01	27.22	27.59	27.92
113.2	112.2	111.3	111.9	111.9	113.7	112.2	111.7	110.5	110.3
74.8	73.6	73.0	71.7	71.6	77.2	75.7	75.4	73.2	73.3
74.5	75.5	71.2	70.9	70.5	73.2	74.6	71.5	65.3	67.4
133.4	132.2	132.1	124.8	124.7	132.0	130.9	130.9	122.3	122.1
51.0	52.0	52.0	52.1	52.1	52.2	53.5	53.5	53.6	53.6
21.43	21.83	21.82	21.90	21.89	21.92	22.48	22.47	22.53	22.52
111.2	**110.3**	**109.6**	**104.6**	**104.4**	**110.6**	**109.7**	**109.1**	**102.2**	**102.3**

Table D13. Natural Gas Supply and Disposition
(Trillion Cubic Feet per Year)

Supply and Disposition	1999	Projections									
		2005					2010				
		Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Production											
Dry Gas Production[1]	18.67	21.32	20.45	21.09	20.02	20.74	23.36	21.81	24.24	21.89	23.09
Supplemental Natural Gas[2]	0.10	0.11	0.11	0.11	0.11	0.11	0.06	0.06	0.06	0.06	0.06
Net Imports	**3.38**	**4.70**	**4.64**	**4.48**	**4.29**	**4.33**	**5.01**	**4.75**	**5.16**	**4.61**	**4.91**
Canada	3.29	4.49	4.43	4.27	4.09	4.12	4.72	4.48	4.86	4.35	4.63
Mexico	-0.01	-0.18	-0.18	-0.18	-0.18	-0.18	-0.25	-0.25	-0.25	-0.25	-0.25
Liquefied Natural Gas	0.10	0.39	0.39	0.39	0.38	0.39	0.53	0.51	0.54	0.51	0.53
Total Supply	**22.15**	**26.14**	**25.20**	**25.69**	**24.42**	**25.18**	**28.42**	**26.61**	**29.45**	**26.56**	**28.06**
Consumption by Sector											
Residential	4.75	5.40	5.39	5.35	5.26	5.22	5.39	5.39	5.27	5.22	5.12
Commercial	3.06	3.89	3.84	3.83	3.81	3.78	4.08	4.01	3.95	4.01	3.93
Industrial[3]	8.31	8.78	8.70	8.70	8.65	8.59	9.48	9.29	9.37	9.04	8.93
Electric Generators[4]	3.76	5.44	4.72	5.20	4.21	5.02	6.83	5.39	8.11	5.78	7.44
Lease and Plant Fuel[5]	1.23	1.36	1.32	1.35	1.30	1.33	1.50	1.42	1.53	1.42	1.48
Pipeline Fuel	0.64	0.80	0.77	0.79	0.75	0.78	0.88	0.83	0.92	0.83	0.88
Transportation[6]	0.02	0.05	0.05	0.05	0.05	0.05	0.09	0.09	0.09	0.08	0.08
Total	**21.77**	**25.73**	**24.79**	**25.27**	**24.02**	**24.77**	**28.24**	**26.41**	**29.24**	**26.37**	**27.86**
Discrepancy[7]	**0.38**	**0.41**	**0.41**	**0.41**	**0.40**	**0.41**	**0.19**	**0.20**	**0.21**	**0.19**	**0.20**

[1]Marketed production (wet) minus extraction losses.
[2]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
[3]Includes consumption by cogenerators.
[4]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[5]Represents natural gas used in the field gathering and processing plant machinery.
[6]Compressed natural gas used as vehicle fuel.
[7]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems which vary in scope, format, definition, and respondent type. In addition, 1999 values include net storage injections.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 supplemental natural gas: Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). 1999 transportation sector consumption: EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. Other 1999 consumption: EIA, *Short-Term Energy Outlook, April 2001,* http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr01.pdf with adjustments to end-use sector consumption levels for consumption of natural gas by electric wholesale generators based on EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF -JL Advanced with Emissions Limits
26.50	23.69	25.89	23.17	24.48	29.34	25.45	27.43	24.89	25.96
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5.44	**4.99**	**5.49**	**4.86**	**5.14**	**5.78**	**5.21**	**5.62**	**5.13**	**5.33**
5.12	4.69	5.17	4.58	4.84	5.39	4.89	5.26	4.81	4.99
-0.33	-0.33	-0.33	-0.33	-0.33	-0.40	-0.40	-0.40	-0.40	-0.40
0.65	0.62	0.65	0.61	0.64	0.79	0.73	0.77	0.72	0.74
32.00	**28.73**	**31.43**	**28.09**	**29.68**	**35.17**	**30.71**	**33.11**	**30.07**	**31.35**
5.63	5.64	5.50	5.39	5.29	5.92	5.95	5.81	5.62	5.53
4.24	4.14	4.10	4.09	4.02	4.36	4.24	4.29	4.20	4.14
10.03	9.72	9.95	9.30	9.20	10.52	10.20	10.57	9.70	9.62
9.12	6.50	8.98	6.66	8.39	11.15	7.42	9.36	7.73	9.15
1.68	1.54	1.64	1.52	1.58	1.86	1.66	1.75	1.63	1.68
0.98	0.89	0.96	0.86	0.92	1.07	0.93	1.01	0.91	0.96
0.13	0.12	0.12	0.10	0.10	0.15	0.15	0.14	0.13	0.12
31.81	**28.55**	**31.25**	**27.92**	**29.50**	**35.03**	**30.56**	**32.94**	**29.92**	**31.19**
0.18	**0.18**	**0.18**	**0.17**	**0.18**	**0.15**	**0.16**	**0.17**	**0.15**	**0.16**

Table D14. Natural Gas Prices, Margins, and Revenue
(1999 Dollars per Thousand Cubic Feet, Unless Otherwise Noted)

Prices, Margins, and Revenue	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Source Price											
Average Lower 48 Wellhead Price[1]	2.08	2.99	2.80	2.83	2.52	2.72	2.82	2.45	2.91	2.28	2.76
Average Import Price	2.29	2.99	2.95	2.99	2.80	2.93	2.66	2.55	2.78	2.44	2.70
Average[2]	**2.11**	**2.99**	**2.83**	**2.86**	**2.57**	**2.76**	**2.79**	**2.47**	**2.89**	**2.31**	**2.75**
Delivered Prices											
Residential	6.69	7.33	7.17	7.22	6.93	7.13	6.88	6.56	7.00	6.43	6.87
Commercial	5.49	5.72	5.56	5.60	5.30	5.50	5.78	5.46	5.89	5.31	5.74
Industrial[3]	2.87	3.76	3.59	3.63	3.33	3.53	3.55	3.20	3.65	3.04	3.51
Electric Generators[4]	2.62	3.49	3.30	3.56	3.11	3.45	3.30	2.88	3.66	2.86	3.48
Transportation[5]	7.21	7.50	7.31	7.35	6.98	7.18	7.36	7.02	7.46	6.78	7.23
Average[6]	**4.14**	**4.85**	**4.72**	**4.78**	**4.50**	**4.68**	**4.55**	**4.27**	**4.66**	**4.13**	**4.54**
Transmission & Distribution Margins[7]											
Residential	4.58	4.34	4.34	4.36	4.36	4.37	4.09	4.09	4.11	4.12	4.13
Commercial	3.37	2.73	2.73	2.74	2.73	2.74	2.99	2.99	3.00	2.99	2.99
Industrial[3]	0.76	0.78	0.77	0.77	0.76	0.77	0.76	0.73	0.77	0.73	0.76
Electric Generators[4]	0.51	0.50	0.47	0.70	0.54	0.69	0.51	0.41	0.78	0.55	0.74
Transportation[5]	5.10	4.52	4.48	4.49	4.41	4.42	4.57	4.55	4.58	4.47	4.48
Average[6]	**2.03**	**1.87**	**1.90**	**1.92**	**1.93**	**1.92**	**1.76**	**1.80**	**1.78**	**1.81**	**1.79**
Transmission & Distribution Revenue (billion 1999 dollars)											
Residential	21.77	23.45	23.39	23.32	22.92	22.81	22.07	22.07	21.68	21.49	21.14
Commercial	10.32	10.62	10.49	10.52	10.42	10.35	12.19	12.01	11.84	12.02	11.78
Industrial[3]	6.28	6.82	6.70	6.74	6.57	6.64	7.20	6.81	7.19	6.61	6.81
Electric Generators[4]	1.90	2.74	2.24	3.63	2.28	3.45	3.46	2.23	6.32	3.18	5.47
Transportation[5]	0.08	0.24	0.23	0.23	0.21	0.21	0.40	0.39	0.39	0.34	0.34
Total	**40.35**	**43.87**	**43.05**	**44.44**	**42.40**	**43.46**	**45.33**	**43.52**	**47.43**	**43.64**	**45.54**

[1]Represents lower 48 onshore and offshore supplies.
[2]Quantity-weighted average of the average lower 48 wellhead price and the average price of imports at the U.S. border.
[3]Includes consumption by cogenerators.
[4]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[5]Compressed natural gas used as a vehicle fuel. Price includes estimated motor vehicle fuel taxes.
[6]Weighted average prices and margins. Weights used are the sectoral consumption values excluding lease, plant, and pipeline fuel.
[7]Within the table, "transmission and distribution" margins equal the difference between the delivered price and the source price (average of the wellhead price and the price of imports at the U.S. border) of natural gas and, thus, reflect the total cost of bringing natural gas to market. When the term "transmission and distribution" margins is used in today's natural gas market, it generally does not include the cost of independent natural gas marketers or costs associated with aggregation of supplies, provisions of storage, and other services. As used here, the term includes the cost of all services and the cost of pipeline fuel used in compressor stations.

CEF = Clean Energy Future.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.

Sources: 1999 industrial delivered prices based on Energy Information Administration (EIA), *Manufacturing Energy Consumption Survey 1994*. 1999 residential and commercial delivered prices, average lower 48 wellhead price, and average import price: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). **Other 1999 values and projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
2.92	2.48	2.91	2.37	2.71	3.10	2.48	2.82	2.36	2.61
2.65	2.48	2.73	2.39	2.62	2.71	2.49	2.73	2.39	2.60
2.87	**2.48**	**2.87**	**2.37**	**2.69**	**3.03**	**2.48**	**2.80**	**2.36**	**2.61**
6.77	6.35	6.78	6.26	6.60	6.74	6.14	6.49	6.03	6.32
5.76	5.34	5.76	5.22	5.56	5.82	5.22	5.57	5.09	5.36
3.66	3.20	3.62	3.08	3.43	3.84	3.19	3.55	3.07	3.35
3.46	2.90	3.62	2.91	3.38	3.68	2.91	3.57	2.96	3.33
7.48	7.04	7.47	6.82	7.16	7.50	6.91	7.23	6.65	6.92
4.52	**4.17**	**4.56**	**4.07**	**4.37**	**4.61**	**4.08**	**4.43**	**3.98**	**4.23**
3.90	3.87	3.91	3.89	3.91	3.71	3.66	3.69	3.67	3.71
2.89	2.86	2.88	2.85	2.86	2.79	2.74	2.76	2.72	2.75
0.78	0.72	0.75	0.71	0.74	0.81	0.71	0.75	0.71	0.74
0.58	0.42	0.74	0.54	0.69	0.66	0.43	0.76	0.60	0.72
4.60	4.56	4.60	4.45	4.47	4.47	4.44	4.43	4.29	4.31
1.65	**1.69**	**1.68**	**1.70**	**1.68**	**1.59**	**1.60**	**1.63**	**1.62**	**1.62**
21.94	21.82	21.51	20.96	20.72	21.95	21.78	21.43	20.63	20.51
12.25	11.83	11.81	11.65	11.52	12.16	11.63	11.84	11.42	11.39
7.85	7.01	7.45	6.60	6.81	8.50	7.29	7.89	6.89	7.16
5.32	2.74	6.66	3.59	5.79	7.33	3.23	7.15	4.64	6.58
0.58	0.55	0.55	0.47	0.46	0.68	0.65	0.64	0.54	0.53
47.93	**43.95**	**47.96**	**43.25**	**45.31**	**50.61**	**44.58**	**48.94**	**44.12**	**46.17**

Table D15. Oil and Gas Supply

Production and Supply	1999	Projections 2005 Reference	2005 CEF Moderate	2005 CEF-JL Moderate with Emissions Limits	2005 CEF-JL Advanced	2005 CEF-JL Advanced with Emissions Limits	2010 Reference	2010 CEF Moderate	2010 CEF-JL Moderate with Emissions Limits	2010 CEF-JL Advanced	2010 CEF-JL Advanced with Emissions Limits
Crude Oil											
Lower 48 Average Wellhead Price[1] (1999 dollars per barrel)	**16.49**	**20.48**	**20.49**	**20.51**	**20.46**	**20.46**	**20.80**	**20.76**	**20.86**	**20.96**	**20.95**
Production (million barrels per day)[2]											
U.S. Total	**5.88**	**5.69**	**5.67**	**5.68**	**5.68**	**5.68**	**5.30**	**5.28**	**5.27**	**5.23**	**5.26**
Lower 48 Onshore	3.27	2.80	2.80	2.81	2.80	2.80	2.50	2.49	2.50	2.47	2.50
Conventional	2.59	2.18	2.17	2.17	2.16	2.16	1.81	1.78	1.80	1.76	1.79
Enhanced Oil Recovery	0.68	0.62	0.63	0.64	0.63	0.64	0.69	0.70	0.69	0.71	0.71
Lower 48 Offshore	1.56	2.09	2.08	2.08	2.09	2.09	2.16	2.15	2.12	2.11	2.12
Alaska	1.05	0.79	0.79	0.79	0.79	0.79	0.65	0.65	0.65	0.65	0.65
Lower 48 End of Year Reserves[2] (billion barrels)	**18.33**	**15.76**	**15.74**	**15.77**	**15.78**	**15.76**	**14.43**	**14.36**	**14.41**	**14.27**	**14.39**
Natural Gas											
Lower 48 Average Wellhead Price[1] (1999 dollars per thousand cubic feet)	**2.08**	**2.99**	**2.80**	**2.83**	**2.52**	**2.72**	**2.82**	**2.45**	**2.91**	**2.28**	**2.76**
Dry Production (trillion cubic feet)[3]											
U.S. Total	**18.67**	**21.32**	**20.45**	**21.09**	**20.02**	**20.74**	**23.36**	**21.81**	**24.24**	**21.89**	**23.09**
Lower 48 Onshore	12.83	14.37	13.75	14.15	13.44	13.91	16.42	15.39	16.84	15.24	16.06
Associated-Dissolved[4]	1.80	1.51	1.51	1.51	1.51	1.51	1.32	1.31	1.32	1.30	1.32
Non-Associated	11.03	12.86	12.24	12.64	11.92	12.40	15.10	14.08	15.52	13.94	14.75
Conventional	6.64	7.62	7.25	7.51	7.04	7.34	7.79	7.54	7.98	7.86	7.59
Unconventional	4.39	5.24	4.99	5.13	4.88	5.06	7.30	6.55	7.54	6.08	7.15
Lower 48 Offshore	5.43	6.49	6.24	6.48	6.12	6.36	6.44	5.92	6.90	6.16	6.53
Associated-Dissolved[4]	0.93	1.06	1.06	1.06	1.07	1.07	1.09	1.09	1.09	1.10	1.09
Non-Associated	4.50	5.42	5.17	5.42	5.05	5.30	5.35	4.83	5.82	5.06	5.44
Alaska	0.42	0.47	0.46	0.46	0.46	0.46	0.50	0.50	0.49	0.49	0.49
Lower 48 End of Year Dry Reserves[3] (trillion cubic feet)	**157.41**	**169.38**	**170.64**	**170.85**	**171.60**	**171.95**	**184.15**	**177.59**	**181.09**	**167.11**	**181.36**
Supplemental Gas Supplies[5] (trillion cubic feet)	**0.10**	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
Total Lower 48 Wells (thousands)	**17.93**	**29.02**	**27.77**	**27.63**	**25.40**	**27.10**	**29.30**	**25.50**	**29.61**	**23.75**	**28.50**

[1]Represents lower 48 onshore and offshore supplies.
[2]Includes lease condensate.
[3]Marketed production (wet) minus extraction losses.
[4]Gas which occurs in crude oil reserves either as free gas (associated) or as gas in solution with crude oil (dissolved).
[5]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 lower 48 onshore, lower 48 offshore, and Alaska crude oil production: Energy Information Administration (EIA), *Petroleum Supply Annual 1999,* DOE/EIA-0340(99/1) (Washington, DC, June 2000). 1999 natural gas lower 48 average wellhead price, Alaska and total natural gas production, and supplemental gas supplies: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2000/06) (Washington, DC, June 2000). Other 1999 values: EIA, Office of Integrated Analysis and Forecasting. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
21.16	**20.94**	**20.96**	**21.12**	**21.17**	**21.50**	**21.43**	**21.34**	**21.43**	**21.44**
5.23	**5.15**	**5.22**	**5.08**	**5.18**	**5.22**	**5.07**	**5.17**	**5.06**	**5.11**
2.56	2.52	2.56	2.49	2.53	2.71	2.61	2.68	2.59	2.65
1.77	1.72	1.77	1.70	1.75	1.96	1.88	1.95	1.86	1.92
0.79	0.80	0.78	0.80	0.78	0.74	0.73	0.73	0.74	0.73
1.98	1.93	1.97	1.88	1.94	1.88	1.82	1.86	1.83	1.82
0.70	0.70	0.70	0.70	0.70	0.64	0.64	0.64	0.64	0.64
13.99	**13.73**	**13.95**	**13.54**	**13.78**	**14.01**	**13.62**	**13.86**	**13.44**	**13.71**
2.92	**2.48**	**2.91**	**2.37**	**2.71**	**3.10**	**2.48**	**2.82**	**2.36**	**2.61**
26.50	**23.69**	**25.89**	**23.17**	**24.48**	**29.34**	**25.45**	**27.43**	**24.89**	**25.96**
19.04	16.97	18.44	16.16	17.31	21.10	18.57	19.92	18.06	18.98
1.30	1.27	1.30	1.26	1.29	1.38	1.34	1.38	1.33	1.36
17.74	15.70	17.14	14.90	16.02	19.72	17.22	18.54	16.73	17.61
9.54	9.01	9.26	9.27	8.78	11.05	10.40	10.38	10.50	10.14
8.20	6.69	7.87	5.63	7.24	8.66	6.83	8.16	6.23	7.47
6.92	6.19	6.93	6.49	6.65	7.66	6.33	6.96	6.28	6.44
1.06	1.06	1.06	1.05	1.06	1.04	1.02	1.03	1.03	1.03
5.86	5.13	5.87	5.44	5.59	6.63	5.31	5.92	5.25	5.42
0.54	0.53	0.52	0.52	0.52	0.57	0.55	0.55	0.55	0.55
195.05	**183.39**	**192.00**	**168.28**	**190.38**	**199.35**	**190.58**	**199.18**	**175.54**	**198.28**
0.06	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
32.27	**28.43**	**32.12**	**27.20**	**30.41**	**38.07**	**32.33**	**34.78**	**30.37**	**32.22**

Table D16. Coal Supply, Disposition, and Prices
(Million Short Tons per Year, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections 2005 Reference	2005 CEF-JL Moderate	2005 CEF-JL Moderate with Emissions Limits	2005 CEF-JL Advanced	2005 CEF-JL Advanced with Emissions Limits	2010 Reference	2010 CEF-JL Moderate	2010 CEF-JL Moderate with Emissions Limits	2010 CEF-JL Advanced	2010 CEF-JL Advanced with Emissions Limits
Production[1]											
Appalachia	434	432	417	364	402	352	425	410	283	358	279
Interior	182	185	179	144	167	143	183	183	123	157	120
West	486	612	623	538	552	525	681	676	410	509	437
East of the Mississippi	558	569	548	482	521	465	564	548	400	474	393
West of the Mississippi	544	659	671	564	600	556	725	721	416	551	442
Total	**1102**	**1228**	**1219**	**1046**	**1121**	**1020**	**1289**	**1270**	**817**	**1025**	**836**
Net Imports											
Imports	9	16	16	12	12	12	17	17	9	9	9
Exports	58	60	60	60	60	60	58	58	60	57	60
Total	**-49**	**-44**	**-44**	**-48**	**-48**	**-48**	**-40**	**-40**	**-51**	**-49**	**-51**
Total Supply[2]	**1053**	**1184**	**1175**	**997**	**1073**	**972**	**1249**	**1229**	**766**	**976**	**785**
Consumption by Sector											
Residential and Commercial	5	5	5	5	5	5	5	5	5	5	5
Industrial[3]	79	82	82	82	78	78	83	81	80	75	73
Coke Plants	28	25	25	25	24	24	23	23	23	19	19
Electric Generators[4]	920	1073	1064	886	968	867	1139	1121	658	876	687
Total	**1031**	**1185**	**1176**	**998**	**1074**	**973**	**1250**	**1231**	**766**	**976**	**785**
Discrepancy and Stock Change[5]	**21**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-2**	**-0**	**0**	**-0**
Average Minemouth Price											
(1999 dollars per short ton)	17.13	15.22	14.79	14.66	14.94	14.46	14.19	13.93	15.08	13.88	14.27
(1999 dollars per million Btu)	0.82	0.74	0.72	0.70	0.72	0.69	0.69	0.68	0.70	0.67	0.67
Delivered Prices[6] (1999 dollars per short ton)											
Industrial	31.37	29.65	29.38	28.66	29.34	28.57	28.56	28.26	26.35	27.77	26.16
Coke Plants	44.38	42.40	42.43	42.52	42.58	42.46	41.25	41.15	41.62	41.10	40.92
Electric Generators											
(1999 dollars per short ton)	24.69	22.92	22.59	21.42	22.37	21.26	21.26	20.92	21.16	20.51	20.77
(1999 dollars per million Btu)	1.21	1.13	1.13	1.05	1.11	1.04	1.06	1.05	1.00	1.02	1.00
Average	**25.74**	**23.80**	**23.49**	**22.55**	**23.32**	**22.37**	**22.11**	**21.79**	**22.32**	**21.48**	**21.77**
Exports[7]	37.50	36.41	36.29	35.91	36.32	35.86	35.57	35.37	34.64	35.06	33.96

[1]Includes anthracite, bituminous coal, lignite, and waste coal delivered to independent power producers. Waste coal deliveries totaled 8.5 million tons in 1995, 8.8 million tons in 1996, 8.1 million tons in 1997, 8.6 million tons in 1998, and are projected to reach 9.6 million tons in 1999, and 12.2 million tons in 2000.
[2]Production plus net imports and net storage withdrawals.
[3]Includes consumption by cogenerators.
[4]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators.
[5]Balancing item: the sum of production, net imports, and net storage minus total consumption.
[6]Sectoral prices weighted by consumption tonnage; weighted average excludes residential/ commercial prices and export free-alongside-ship (f.a.s.) prices.
[7]F.a.s. price at U.S. port of exit.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 data based on Energy Information Administration (EIA), *Quarterly Coal Report*, DOE/EIA-0121(2000/1Q) (Washington, DC, August 2000) and EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
404	391	274	321	272	396	384	258	275	254
171	171	126	126	119	164	166	117	99	117
742	727	395	551	411	775	757	412	580	395
536	523	394	411	385	526	515	370	348	365
782	766	401	587	417	810	794	418	606	400
1317	**1289**	**794**	**998**	**802**	**1336**	**1308**	**788**	**954**	**766**
18	18	9	9	9	20	20	9	9	9
56	54	60	55	60	56	56	60	58	59
-37	**-35**	**-51**	**-46**	**-51**	**-36**	**-36**	**-51**	**-49**	**-50**
1280	**1254**	**743**	**952**	**751**	**1300**	**1272**	**737**	**905**	**716**
5	5	5	5	5	5	5	5	5	5
84	82	81	74	72	85	83	82	73	72
21	21	21	16	16	19	19	19	13	13
1172	1149	636	858	658	1190	1167	633	814	625
1282	**1257**	**744**	**953**	**751**	**1299**	**1274**	**739**	**906**	**715**
-2	**-3**	**-1**	**-1**	**-0**	**1**	**-2**	**-2**	**-1**	**1**
13.40	13.24	14.44	12.71	13.79	12.93	12.78	13.47	11.51	13.45
0.66	0.65	0.67	0.62	0.64	0.64	0.63	0.63	0.57	0.63
27.43	27.22	25.28	26.43	25.26	26.49	26.19	24.08	24.22	24.11
39.93	39.63	40.18	39.50	39.44	38.50	38.56	38.83	38.02	38.17
20.24	19.96	19.76	19.39	19.34	19.34	19.05	19.07	18.21	18.60
1.02	1.00	0.94	0.98	0.93	0.98	0.96	0.92	0.93	0.89
21.03	**20.77**	**20.94**	**20.28**	**20.34**	**20.09**	**19.81**	**20.14**	**18.99**	**19.53**
34.66	34.18	32.87	33.48	32.43	33.07	33.01	31.82	31.56	31.70

Table D17. Renewable Energy Generating Capability and Generation
(Gigawatts, Unless Otherwise Noted)

Capacity and Generation	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Electric Generators[1] (excluding cogenerators)											
Net Summer Capability											
Conventional Hydropower	78.77	79.26	79.26	79.26	79.26	79.26	79.38	79.38	79.71	79.62	79.62
Geothermal[2]	2.87	3.36	4.33	6.61	6.85	7.79	4.81	5.37	9.50	7.86	9.34
Municipal Solid Waste[3]	2.61	2.96	3.17	3.87	3.95	3.96	3.42	3.66	4.34	4.36	4.36
Wood and Other Biomass[4]	1.57	1.75	1.98	1.89	1.75	1.81	2.12	2.35	2.48	2.12	2.18
Solar Thermal	0.33	0.35	0.35	0.35	0.35	0.35	0.40	0.40	0.40	0.40	0.40
Solar Photovoltaic	0.01	0.08	0.08	0.08	0.08	0.08	0.21	0.21	0.21	0.21	0.21
Wind	2.66	6.92	7.27	8.56	13.36	14.48	7.52	8.43	22.96	31.52	35.43
Total	**88.83**	**94.68**	**96.45**	**100.62**	**105.60**	**107.73**	**97.85**	**99.79**	**119.61**	**126.08**	**131.53**
Generation (billion kilowatthours)											
Conventional Hydropower	309.55	301.20	301.16	301.15	301.15	301.14	301.13	301.04	302.12	301.85	301.85
Geothermal[2]	13.21	17.71	25.79	44.55	46.43	54.16	29.92	34.57	68.42	54.74	66.98
Municipal Solid Waste[3]	18.12	20.68	22.38	27.86	28.49	28.53	23.88	25.68	31.09	31.18	31.19
Wood and Other Biomass[4]	8.76	14.92	15.96	57.92	57.16	59.70	21.22	21.31	65.67	62.27	59.76
Dedicated Plants	7.73	9.17	10.72	10.09	9.20	9.60	11.36	12.91	13.87	11.41	11.81
Cofiring	1.03	5.75	5.24	47.83	47.96	50.10	9.86	8.40	51.80	50.86	47.95
Solar Thermal	0.89	0.96	0.96	0.96	0.96	0.96	1.11	1.11	1.11	1.11	1.11
Solar Photovoltaic	0.03	0.20	0.20	0.20	0.20	0.20	0.51	0.51	0.51	0.51	0.51
Wind	4.61	16.30	17.49	21.85	36.42	40.23	18.16	21.38	73.65	103.09	116.99
Total	**355.16**	**371.97**	**383.94**	**454.49**	**470.82**	**484.92**	**395.92**	**405.60**	**542.57**	**554.75**	**578.39**
Cogenerators[5]											
Net Summer Capability											
Municipal Solid Waste	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Biomass	4.65	5.19	5.15	5.15	5.32	5.31	6.09	5.99	5.99	6.57	6.55
Total	**5.35**	**5.89**	**5.85**	**5.85**	**6.02**	**6.01**	**6.79**	**6.69**	**6.69**	**7.27**	**7.25**
Generation (billion kilowatthours)											
Municipal Solid Waste	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
Biomass	27.08	30.04	29.83	29.79	30.81	30.76	35.20	34.62	34.53	38.03	37.92
Total	**31.12**	**34.08**	**33.88**	**33.83**	**34.86**	**34.80**	**39.24**	**38.67**	**38.58**	**42.07**	**41.97**
Other End-Use Generators[6]											
Net Summer Capability											
Conventional Hydropower[7]	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar Photovoltaic	0.01	0.10	0.10	0.10	0.10	0.10	0.35	0.35	0.35	0.35	0.35
Total	**1.00**	**1.09**	**1.09**	**1.09**	**1.09**	**1.09**	**1.34**	**1.34**	**1.34**	**1.34**	**1.34**
Generation (billion kilowatthours)											
Conventional Hydropower[7]	4.57	4.44	4.44	4.44	4.44	4.44	4.43	4.43	4.43	4.43	4.43
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar Photovoltaic	0.02	0.20	0.20	0.20	0.20	0.20	0.75	0.75	0.75	0.75	0.75
Total	**4.59**	**4.64**	**4.64**	**4.64**	**4.64**	**4.64**	**5.18**	**5.18**	**5.18**	**5.18**	**5.18**

[1]Includes grid-connected utilities and nonutilities other than cogenerators. These nonutility facilities include 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. Excludes off-grid photovoltaics and other generators not connected to the distribution or transmission systems.
[7]Represents own-use industrial hydroelectric power.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports. Net summer capability has been estimated for nonutility generators for AEO2001. 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: 1999 electric utility capability: Energy Information Administration (EIA), Form EIA-860A: "Annual Electric Generator Report - Utility." 1999 nonutility and cogenerator capability: EIA, Form EIA-860B: "Annual Electric Generator Report - Nonutility." 1999 generation: EIA, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
79.38	79.38	79.71	79.62	79.62	79.38	79.38	79.71	79.62	79.62
4.83	5.37	9.50	7.87	9.34	4.83	5.37	9.59	7.87	9.34
3.79	4.02	4.72	4.72	4.72	3.93	4.17	4.86	4.87	4.87
2.40	2.63	2.80	2.40	2.46	2.45	2.68	2.92	2.45	2.51
0.44	0.44	0.44	0.44	0.44	0.48	0.48	0.48	0.48	0.48
0.37	0.37	0.37	0.37	0.37	0.54	0.54	0.54	0.54	0.54
7.72	8.66	25.00	32.28	35.62	7.74	9.36	44.80	32.31	35.65
98.92	**100.88**	**122.53**	**127.70**	**132.58**	**99.35**	**101.97**	**142.91**	**128.13**	**133.01**
300.57	300.43	301.50	301.21	301.20	300.06	299.85	300.91	300.60	300.59
30.10	34.59	68.44	54.75	67.00	30.13	34.60	69.25	54.76	67.00
26.72	28.50	33.95	33.99	34.00	27.76	29.52	34.97	35.00	35.01
22.27	20.82	63.70	59.58	52.93	19.29	21.21	61.08	51.69	37.65
13.47	15.02	16.22	13.52	13.92	13.82	15.36	17.03	13.86	14.27
8.79	5.80	47.48	46.06	39.01	5.47	5.85	44.05	37.82	23.38
1.24	1.24	1.24	1.24	1.24	1.37	1.37	1.37	1.37	1.37
0.92	0.92	0.92	0.92	0.92	1.36	1.36	1.36	1.36	1.36
18.67	22.03	80.44	105.91	117.50	18.77	24.66	155.05	106.01	117.60
400.49	**408.53**	**550.19**	**557.60**	**574.79**	**398.74**	**412.57**	**623.99**	**550.78**	**560.59**
0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
6.90	6.74	6.73	7.79	7.77	7.59	7.38	7.35	8.96	8.95
7.60	**7.44**	**7.43**	**8.48**	**8.47**	**8.29**	**8.08**	**8.05**	**9.66**	**9.65**
4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
39.84	38.94	38.77	45.11	45.03	43.82	42.65	42.39	52.01	51.94
43.88	**42.98**	**42.81**	**49.16**	**49.08**	**47.87**	**46.69**	**46.44**	**56.05**	**55.99**
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
1.34	**1.34**	**1.34**	**1.34**	**1.34**	**1.34**	**1.34**	**1.34**	**1.34**	**1.34**
4.42	4.42	4.42	4.42	4.42	4.41	4.41	4.41	4.41	4.41
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5.18	**5.18**	**5.18**	**5.18**	**5.18**	**5.17**	**5.17**	**5.17**	**5.17**	**5.17**

Table D18. Renewable Energy Consumption by Sector and Source[1]
(Quadrillion Btu per Year)

Sector and Source	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Marketed Renewable Energy[2]											
Residential	**0.41**	**0.42**	**0.42**	**0.42**	**0.41**	**0.41**	**0.42**	**0.42**	**0.42**	**0.41**	**0.41**
Wood	0.41	0.42	0.42	0.42	0.41	0.41	0.42	0.42	0.42	0.41	0.41
Commercial	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Biomass	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Industrial[3]	**2.15**	**2.40**	**2.39**	**2.39**	**2.43**	**2.43**	**2.63**	**2.60**	**2.60**	**2.75**	**2.75**
Conventional Hydroelectric	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Municipal Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	1.97	2.22	2.20	2.20	2.25	2.24	2.44	2.41	2.41	2.56	2.56
Transportation	**0.12**	**0.20**	**0.20**	**0.20**	**0.18**	**0.18**	**0.21**	**0.22**	**0.22**	**0.19**	**0.19**
Ethanol used in E85[4]	0.00	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02
Ethanol used in Gasoline Blending	0.12	0.18	0.18	0.18	0.17	0.17	0.19	0.19	0.19	0.17	0.17
Electric Generators[5]	**3.88**	**4.17**	**4.47**	**5.58**	**5.80**	**6.11**	**4.70**	**4.90**	**7.04**	**6.86**	**7.30**
Conventional Hydroelectric	3.19	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.11	3.11	3.11
Geothermal	0.28	0.42	0.68	1.25	1.32	1.57	0.82	0.97	2.03	1.59	1.99
Municipal Solid Waste[6]	0.25	0.28	0.31	0.38	0.39	0.39	0.32	0.35	0.42	0.42	0.42
Biomass	0.11	0.18	0.19	0.61	0.61	0.63	0.25	0.25	0.71	0.67	0.65
Dedicated Plants	0.10	0.11	0.13	0.11	0.10	0.10	0.14	0.15	0.15	0.12	0.13
Cofiring	0.01	0.07	0.06	0.51	0.51	0.53	0.12	0.10	0.56	0.55	0.52
Solar Thermal	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Solar Photovoltaic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind	0.05	0.17	0.18	0.22	0.37	0.41	0.19	0.22	0.76	1.06	1.10
Total Marketed Renewable Energy	**6.64**	**7.27**	**7.56**	**8.67**	**8.91**	**9.22**	**8.05**	**8.23**	**10.36**	**10.30**	**10.73**
Non-Marketed Renewable Energy[7]											
Selected Consumption											
Residential	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Solar Hot Water Heating	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Geothermal Heat Pumps	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
Solar Photovoltaic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Solar Thermal	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Solar Photovoltaic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ethanol											
From Corn	0.12	0.19	0.19	0.19	0.17	0.17	0.19	0.19	0.19	0.16	0.16
From Cellulose	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03
Total	**0.12**	**0.20**	**0.20**	**0.20**	**0.18**	**0.18**	**0.21**	**0.22**	**0.22**	**0.19**	**0.19**

[1]Actual heat rates used to determine fuel consumption for all renewable fuels except hydropower, solar, and wind. Consumption at hydroelectric, solar, and wind facilities determined by using the fossil fuel equivalent of 10,280 Btu per kilowatthour.
[2]Includes nonelectric renewable energy groups for which the energy source is bought and sold in the marketplace, although all transactions may not necessarily be marketed, and marketed renewable energy inputs for electricity entering the marketplace on the electric power grid. Excludes electricity imports; see Table D8.
[3]Includes all electricity production by industrial and other cogenerators for the grid and for own use.
[4]Excludes motor gasoline component of E85.
[5]Includes renewable energy delivered to the grid from electric utilities and nonutilities. Renewable energy used in generating electricity for own use is included in the individual sectoral electricity energy consumption values.
[6]Includes landfill gas.
[7]Includes selected renewable energy consumption data for which the energy is not bought or sold, either directly or indirectly as an input to marketed energy. The Energy Information Administration does not estimate or project total consumption of nonmarketed renewable energy.
Btu = British thermal unit.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 ethanol: Energy Information Administration (EIA), *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). 1999 electric generators: EIA, Form EIA-860A: "Annual Electric Generator Report - Utility" and Form EIA-860B: "Annual Electric Generator Report - Nonutility." Other 1999: EIA, Office of Integrated Analysis and Forecasting. **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
0.43	**0.43**	**0.42**	**0.42**	**0.41**	**0.43**	**0.44**	**0.42**	**0.43**	**0.42**
0.43	0.43	0.42	0.42	0.41	0.43	0.44	0.42	0.43	0.42
0.08	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
2.85	**2.81**	**2.81**	**3.08**	**3.08**	**3.07**	**3.03**	**3.02**	**3.43**	**3.43**
0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.67	2.63	2.62	2.89	2.89	2.89	2.84	2.84	3.25	3.25
0.23	**0.39**	**0.39**	**0.34**	**0.34**	**0.24**	**0.77**	**0.76**	**0.57**	**0.57**
0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.04	0.04
0.19	0.36	0.35	0.31	0.31	0.21	0.72	0.72	0.53	0.53
4.76	**4.95**	**7.13**	**6.91**	**7.27**	**4.75**	**4.99**	**7.91**	**6.84**	**7.13**
3.09	3.09	3.10	3.10	3.10	3.08	3.08	3.10	3.09	3.09
0.82	0.97	2.03	1.59	1.99	0.82	0.97	2.06	1.59	1.99
0.36	0.39	0.46	0.46	0.46	0.38	0.40	0.48	0.48	0.48
0.27	0.25	0.69	0.65	0.58	0.24	0.26	0.67	0.57	0.43
0.17	0.18	0.18	0.15	0.15	0.17	0.19	0.19	0.15	0.16
0.11	0.07	0.52	0.50	0.43	0.07	0.07	0.48	0.42	0.27
0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.19	0.23	0.83	1.09	1.11	0.19	0.25	1.59	1.09	1.11
8.35	**8.67**	**10.84**	**10.83**	**11.19**	**8.58**	**9.31**	**12.21**	**11.36**	**11.64**
0.04	**0.03**	**0.03**	**0.03**	**0.03**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.19	0.14	0.14	0.14	0.14	0.17	0.11	0.11	0.05	0.05
0.04	0.25	0.25	0.20	0.20	0.07	0.66	0.66	0.53	0.53
0.23	**0.39**	**0.39**	**0.34**	**0.34**	**0.24**	**0.77**	**0.76**	**0.57**	**0.57**

Table D19. Carbon Dioxide Emissions by Sector and Source
(Million Metric Tons Carbon Equivalent per Year)

Sector and Source	1999	Projections									
		2005					2010				
		Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Residential											
Petroleum	26.0	26.6	26.5	26.5	25.6	25.6	24.6	24.3	24.4	23.3	23.3
Natural Gas	69.5	79.9	79.6	79.1	77.8	77.2	79.8	79.7	78.0	77.1	75.7
Coal	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3
Electricity	193.4	226.8	221.1	191.2	198.0	185.2	240.3	228.1	163.2	183.1	161.5
Total	**290.1**	**334.5**	**328.5**	**298.0**	**302.5**	**289.3**	**346.0**	**333.4**	**266.9**	**284.8**	**261.9**
Commercial											
Petroleum	13.7	11.9	12.0	12.0	11.4	11.4	12.1	12.1	12.3	11.3	11.3
Natural Gas	45.4	57.5	56.7	56.7	56.4	55.9	60.3	59.4	58.4	59.4	58.2
Coal	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.7	1.7
Electricity	181.3	219.0	208.0	181.0	190.3	177.9	241.0	224.3	163.2	188.3	166.2
Total	**242.1**	**290.1**	**278.4**	**251.4**	**259.8**	**247.0**	**315.1**	**297.6**	**235.7**	**260.7**	**237.5**
Industrial[1]											
Petroleum	104.2	98.8	97.7	97.8	95.7	96.1	104.6	101.2	102.2	98.5	99.1
Natural Gas[2]	141.6	147.7	146.0	146.4	144.8	144.6	159.5	155.9	159.0	152.2	151.7
Coal	55.9	65.6	64.9	65.0	62.8	62.9	65.4	64.2	63.2	60.0	59.1
Electricity	178.8	192.9	189.2	165.7	171.3	160.6	203.7	200.6	144.0	162.2	144.0
Total	**480.4**	**505.0**	**497.7**	**474.9**	**474.6**	**464.2**	**533.2**	**521.9**	**468.4**	**472.9**	**453.9**
Transportation											
Petroleum[3]	485.8	554.7	548.4	547.6	517.6	517.0	606.2	593.1	591.4	539.4	538.7
Natural Gas[4]	9.5	12.6	12.2	12.5	11.8	12.2	14.3	13.5	14.9	13.4	14.2
Other[5]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Electricity	2.9	4.4	4.2	3.7	3.8	3.6	5.8	5.0	3.7	4.1	3.7
Total[3]	**498.2**	**571.8**	**564.9**	**563.8**	**533.3**	**532.9**	**626.3**	**611.6**	**610.2**	**557.0**	**556.6**
Total Carbon Dioxide Emissions by Delivered Fuel											
Petroleum[3]	629.7	692.0	684.6	683.8	650.4	650.1	747.4	730.6	730.3	672.4	672.5
Natural Gas	266.0	297.8	294.5	294.7	290.7	289.9	313.9	308.5	310.3	302.1	299.8
Coal	58.8	68.5	67.9	67.9	65.7	65.9	68.6	67.4	66.4	63.1	62.2
Other[5]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Electricity	556.3	643.1	622.5	541.7	563.3	527.3	690.7	658.0	474.2	537.6	475.3
Total[3]	**1510.8**	**1701.4**	**1669.5**	**1588.2**	**1570.2**	**1533.3**	**1820.6**	**1764.6**	**1581.2**	**1575.3**	**1509.9**
Electric Generators[6]											
Petroleum	20.0	9.1	6.7	2.4	3.4	2.4	5.3	4.4	2.1	2.4	2.0
Natural Gas	45.8	79.8	69.3	76.3	61.7	73.6	100.2	79.1	119.0	84.8	109.1
Coal	490.5	554.2	546.5	463.0	498.2	451.4	585.3	574.6	353.1	450.5	364.2
Total	**556.3**	**643.1**	**622.5**	**541.7**	**563.3**	**527.3**	**690.7**	**658.0**	**474.2**	**537.6**	**475.3**
Total Carbon Dioxide Emissions by Primary Fuel[7]											
Petroleum[3]	649.7	701.1	691.2	686.2	653.8	652.5	752.6	735.0	732.4	674.8	674.5
Natural Gas	311.8	377.5	363.8	371.0	352.4	363.5	414.0	387.6	429.2	386.9	408.9
Coal	549.3	622.7	614.3	530.9	563.9	517.2	653.8	642.0	419.5	513.5	426.5
Other[5]	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total[3]	**1510.8**	**1701.4**	**1669.5**	**1588.2**	**1570.2**	**1533.3**	**1820.6**	**1764.6**	**1581.2**	**1575.3**	**1509.9**
Carbon Dioxide Emissions (tons carbon equivalent per person)	**5.5**	**5.9**	**5.8**	**5.5**	**5.5**	**5.3**	**6.1**	**5.9**	**5.3**	**5.2**	**5.0**

[1]Includes consumption by cogenerators.
[2]Includes lease and plant fuel.
[3]This includes international bunker fuel which, by convention are excluded from the international accounting of carbon dioxide emissions. In the years from 1990 through 1998, international bunker fuels accounted for 25 to 30 million metric tons carbon equivalent of carbon dioxide annually.
[4]Includes pipeline fuel natural gas and compressed natural gas used as vehicle fuel.
[5]Includes methanol and liquid hydrogen.
[6]Includes all electric power generators except cogenerators, which produce electricity and other useful thermal energy. Includes small power producers and exempt wholesale generators. Does not include emissions from the nonbiogenic component of municipal solid waste because under international guidelines these are accounted for as waste not energy.
[7]Emissions from electric power generators are distributed to the primary fuels.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Sources: 1999 emissions and emission factors: Energy Information Administration (EIA), *Emissions of Greenhouse Gases in the United States 1999,* DOE/EIA-0573(99) (Washington, DC, October 2000). **Projections:** EIA, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
23.8	23.3	23.5	22.0	22.1	23.3	22.7	23.0	21.4	21.5
83.2	83.4	81.4	79.7	78.3	87.5	88.0	85.9	83.1	81.8
1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
255.6	231.3	160.4	174.2	154.1	270.7	236.1	161.1	166.5	149.0
363.9	**339.3**	**266.6**	**277.2**	**255.8**	**382.7**	**348.0**	**271.3**	**272.3**	**253.5**
12.2	12.2	12.6	11.0	11.1	12.0	12.1	12.5	10.6	10.7
62.7	61.2	60.6	60.5	59.5	64.4	62.7	63.4	62.1	61.2
1.9	1.9	1.9	1.8	1.8	1.9	1.9	1.9	1.8	1.8
259.2	235.9	166.1	191.5	169.6	268.3	238.9	164.4	186.0	166.2
336.0	**311.2**	**241.1**	**264.7**	**241.9**	**346.6**	**315.6**	**242.3**	**260.5**	**239.9**
108.1	103.1	104.7	99.5	100.2	113.0	105.7	107.4	100.4	101.1
170.6	164.1	169.0	157.6	157.0	180.1	172.8	179.8	165.1	164.6
65.5	64.1	63.5	59.0	58.1	65.6	64.0	63.2	57.9	57.4
214.7	212.4	143.4	165.3	147.1	226.3	223.7	143.8	166.1	149.4
559.0	**543.7**	**480.5**	**481.4**	**462.4**	**585.0**	**566.2**	**494.2**	**489.4**	**472.3**
655.8	630.9	629.5	554.4	553.9	703.5	661.1	659.6	572.1	571.6
16.4	14.9	16.0	14.3	15.1	18.0	16.0	17.0	15.3	16.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7.0	6.1	4.4	4.8	4.3	7.9	7.0	5.0	5.4	4.9
679.2	**652.0**	**650.0**	**573.6**	**573.3**	**729.5**	**684.2**	**681.7**	**592.9**	**592.6**
799.8	769.5	770.2	686.9	687.3	851.8	801.5	802.6	704.5	704.9
333.0	323.7	327.0	312.0	309.8	350.0	339.5	346.1	325.6	323.5
68.7	67.3	66.7	62.1	61.2	68.8	67.2	66.4	60.9	60.5
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
736.5	685.6	474.2	535.8	475.0	773.1	705.8	474.4	524.0	469.4
1938.1	**1846.1**	**1638.2**	**1596.8**	**1533.4**	**2043.8**	**1914.0**	**1689.5**	**1615.2**	**1558.4**
5.1	4.5	2.1	2.2	1.8	4.8	4.3	2.1	1.9	1.8
133.8	95.3	131.7	97.8	123.2	163.6	108.9	137.4	113.4	134.2
597.6	585.8	340.4	435.8	350.0	604.7	592.5	334.9	408.7	333.4
736.5	**685.6**	**474.2**	**535.8**	**475.0**	**773.1**	**705.8**	**474.4**	**524.0**	**469.4**
804.9	774.0	772.4	689.1	689.1	856.5	805.8	804.7	706.4	706.7
466.8	419.0	458.7	409.8	433.0	513.6	448.4	483.5	439.0	457.8
666.3	653.1	407.0	497.9	411.2	673.5	659.7	401.3	469.6	393.9
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1938.1	**1846.1**	**1638.2**	**1596.8**	**1533.4**	**2043.8**	**1914.0**	**1689.5**	**1615.2**	**1558.4**
6.2	**5.9**	**5.2**	**5.1**	**4.9**	**6.3**	**5.9**	**5.2**	**5.0**	**4.8**

Table D20. Emissions, Allowance Costs, and Retrofits: Electric Generators, Excluding Cogenerators

Impacts	1999	Projections									
		2005					2010				
		Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
Emissions											
Nitrogen Oxides (million tons)	5.43	4.30	4.21	2.66	3.87	2.64	4.34	4.20	1.74	3.52	1.78
Sulfur Dioxide (million tons)	13.49	10.39	10.39	6.34	10.39	6.34	9.70	9.70	2.99	9.70	2.99
Mercury (tons)	43.35	45.02	44.86	26.20	42.20	26.20	45.53	45.71	4.30	38.57	4.30
Carbon Dioxide (million metric tons carbon equivalent)	556.3	643.1	622.5	541.7	563.3	527.3	690.7	658.0	474.2	537.6	475.3
Allowance Prices											
Nitrogen Oxides (1999 dollars per ton)											
Summer Seasonal	0	4370	4141	0	56	51	4404	3384	0	0	0
National Annual	0	0	0	1057	0	1093	0	0	0	0	0
Sulfur Dioxide (1999 dollars per ton)	0	184	182	267	137	284	180	169	316	102	130
Mercury (million 1999 dollars per ton)	0	0	0	76	0	58	0	0	549	0	481
Carbon Dioxide (1999 dollars per ton carbon equivalent)	0	0	0	42	50	50	0	0	64	50	54
Retrofits (gigawatts, cumulative from 1999)											
Scrubber [1]	0.0	8.9	3.7	13.1	1.4	9.3	8.9	7.6	42.4	1.4	46.3
Combustion	0.0	40.4	39.5	43.3	37.8	41.9	42.5	41.4	52.3	41.4	54.1
SCR Post-combustion	0.0	90.8	89.9	78.8	78.3	71.0	90.9	89.9	112.3	78.5	101.6
SNCR Post-combustion	0.0	28.5	25.9	25.9	33.5	28.1	28.5	25.9	33.6	33.8	43.1
Mercury Spray Cooler	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.7	0.0	74.7
Mercury Fabric Filter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.2	0.0	110.5
Coal Production by Sulfur Category (million tons)											
Low Sulfur (< .61 lbs. S/mmBtu)	473	582	591	546	514	532	633	621	415	477	438
Medium Sulfur (.61-1.67 lbs. S/mmBtu)	433	456	447	355	429	348	465	457	283	372	274
High Sulfur (> 1.67 lbs. S/mmBtu)	196	190	181	145	178	140	191	192	118	176	124

[1]Represents scrubbers added by the model. Planned scrubbers added by electricity generators are not shown here.
SCR = Selective catalytic reduction.
SNCR = Selective noncatalytic reduction.
lbs. S/mmBtu = Pounds sulfur per million British thermal units.
CEF = Clean Energy Future.
Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.
Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, SCENDEMR.D092701A.

Projections									
2015					2020				
Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits	Reference	CEF-JL Moderate	CEF-JL Moderate with Emissions Limits	CEF-JL Advanced	CEF-JL Advanced with Emissions Limits
4.44	4.28	1.70	3.41	1.71	4.48	4.33	1.67	3.18	1.64
8.95	8.95	2.64	6.70	2.64	8.95	8.95	2.24	4.48	2.24
44.98	45.89	4.30	35.25	4.30	45.23	46.22	4.30	29.36	4.30
736.5	685.6	474.2	535.8	475.0	773.1	705.8	474.4	524.0	469.4
4717	4229	0	0	0	5087	4564	0	0	0
0	0	449	0	511	0	0	81	0	0
252	208	96	306	284	200	184	905	707	670
0	0	485	0	402	0	0	468	0	391
0	0	78	50	51	0	0	68	50	50
14.2	8.2	54.6	1.4	52.1	17.5	9.5	54.9	12.1	52.7
44.4	43.2	53.5	42.9	54.8	46.6	45.5	54.8	44.5	54.8
91.1	89.9	112.3	78.5	101.6	91.1	89.9	112.3	78.5	101.6
36.0	26.0	33.6	33.9	43.4	46.0	31.9	33.6	33.9	43.4
0.0	0.0	56.5	0.0	91.5	0.0	0.0	57.5	0.0	98.3
0.0	0.0	99.0	0.0	114.2	0.0	0.0	100.4	0.0	115.5
692	666	393	522	406	714	686	415	569	429
440	442	271	336	270	442	443	265	262	224
186	181	131	141	126	180	179	108	122	113