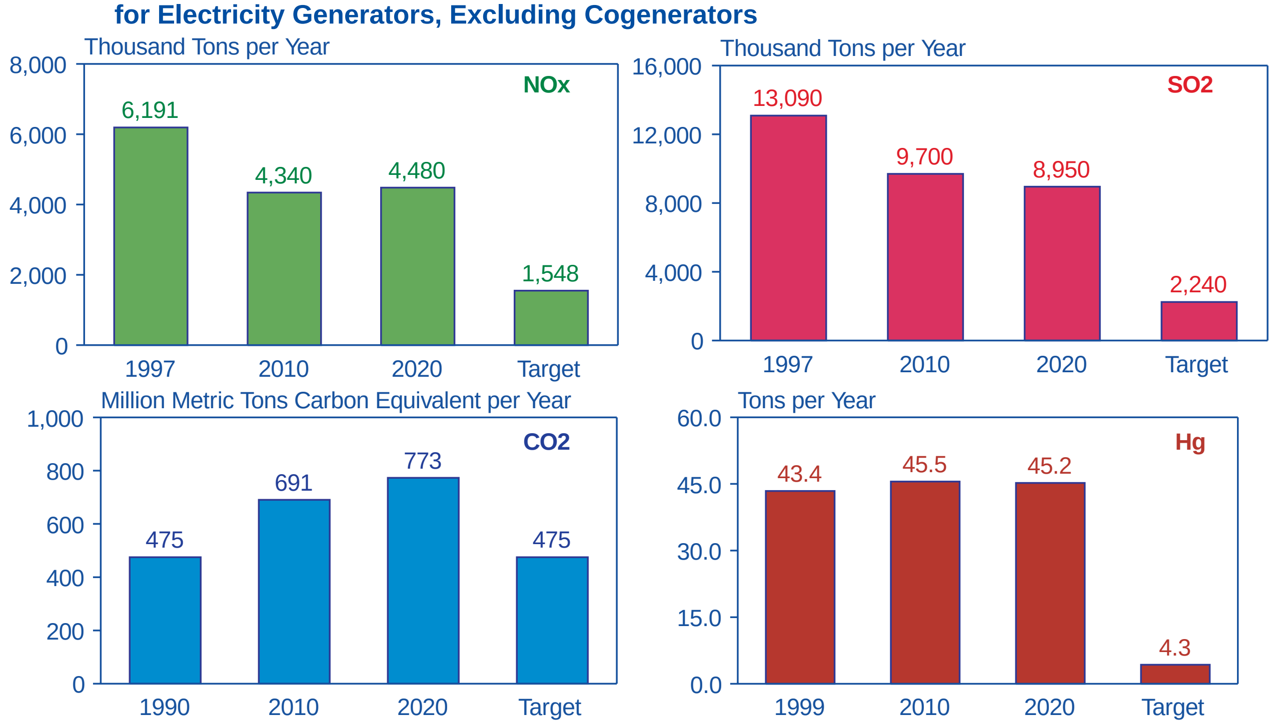
Executive Summary

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.

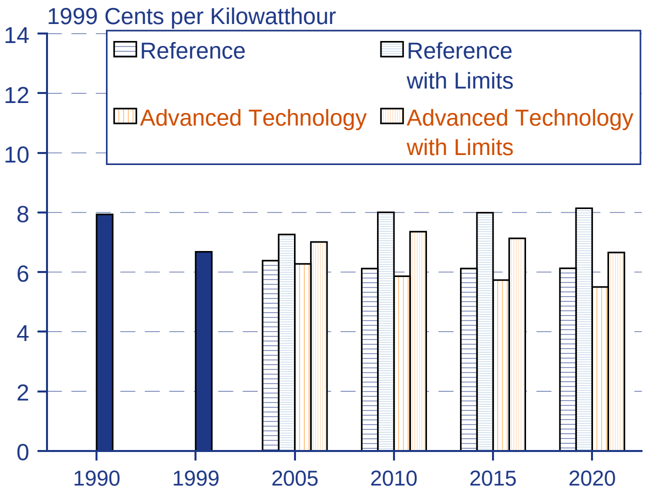
Table ES2. Energy Market Projections in the Reference and Advanced Technology Cases, 2020

		2020			
		Reference		Advanced Technology	
Projections	1999	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.

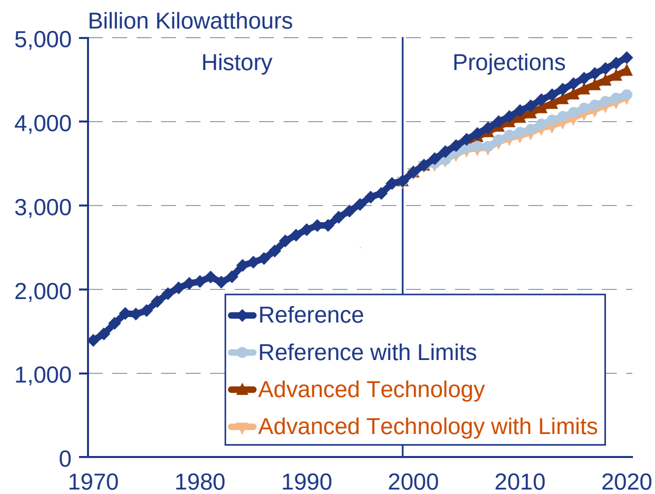
The total cost of supplying electric power, which is called the resource cost, includes the cost of fuel, operations and maintenance costs, investments in plant and equipment, and costs of purchasing power. The resource cost does not include the costs of emissions allowances, which are included in the 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



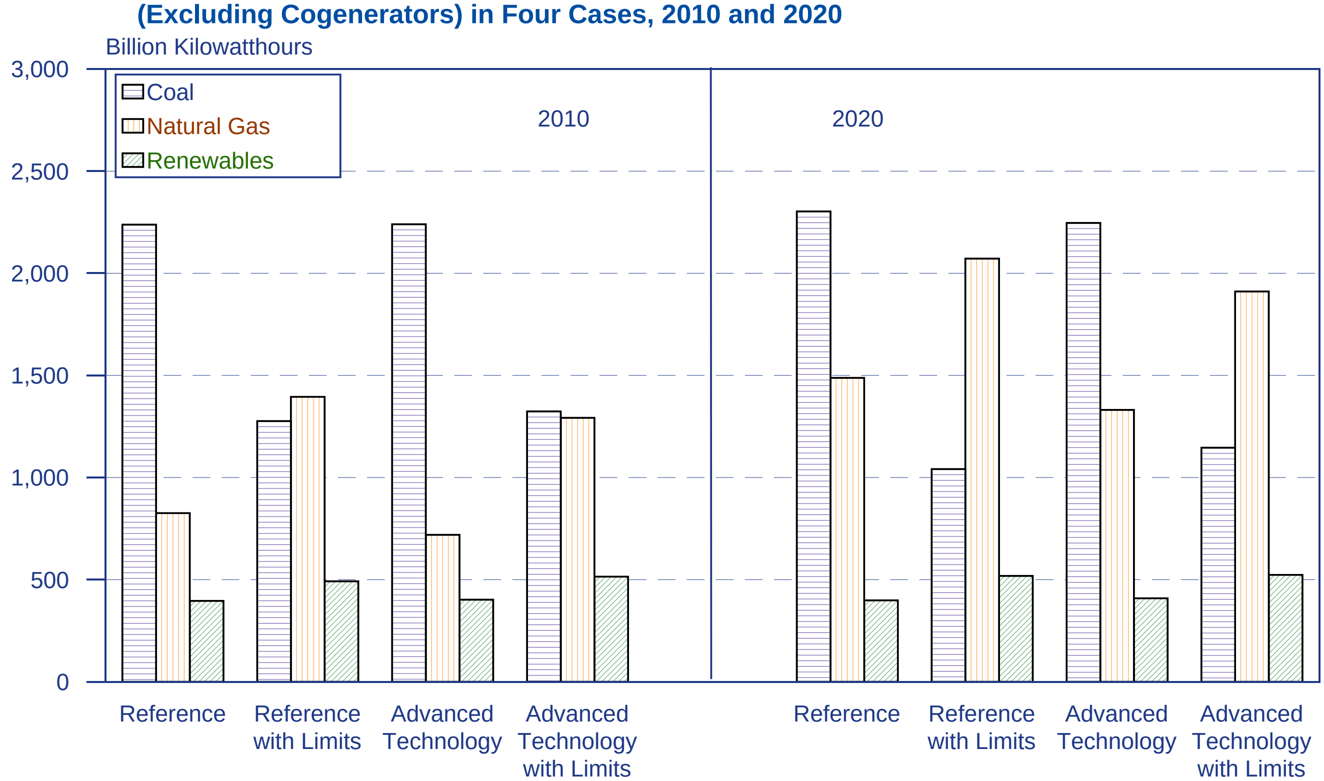
Source: National Energy Modeling System, runs SCENABS. D080301A, SCENAEM.D081601A, SCENBBS.D080301A, and

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.

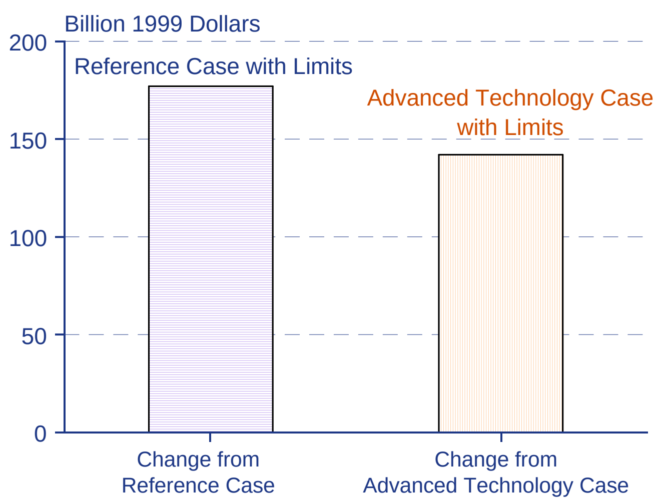
Natural gas consumption is expected to be higher, primarily for electricity generation by generators subject to emissions limits as they reduce coal-fired generation. Higher demand for natural gas is also expected in the commercial and industrial sectors as they increase the cogeneration of electricity, 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: Without Emissions Limits	2007 Reference: With Emissions Limits	2007 Advanced Technology: Without Emissions Limits	2007 Advanced Technology: 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.

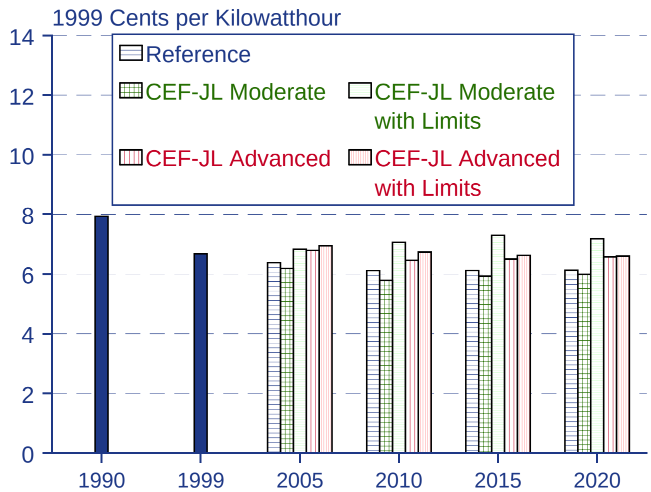
Impacts of Emissions Limits on the CEF-JL Cases

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.

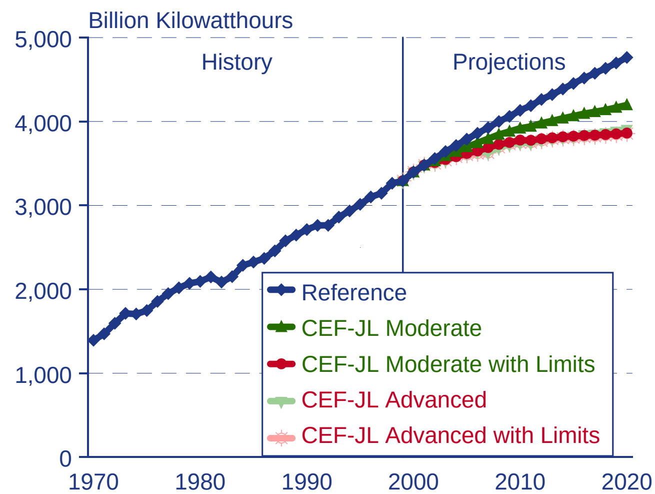
Between 2001 and 2020, the cumulative incremental resource costs to electricity generators to comply with the emissions limits are projected to be $162 billion and $129 billion in the moderate and advanced cases, respectively—increases of 9 and 8 percent (Figure ES8). The lower costs of compliance projected 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

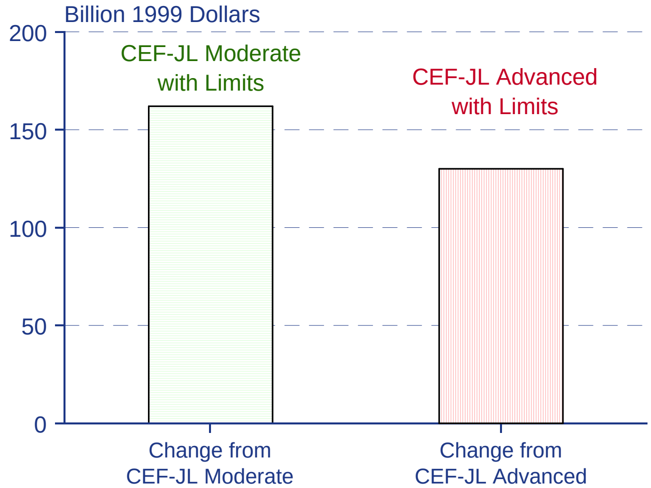


Source: National Energy Modeling System, runs SCENABS.D080301A, SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

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

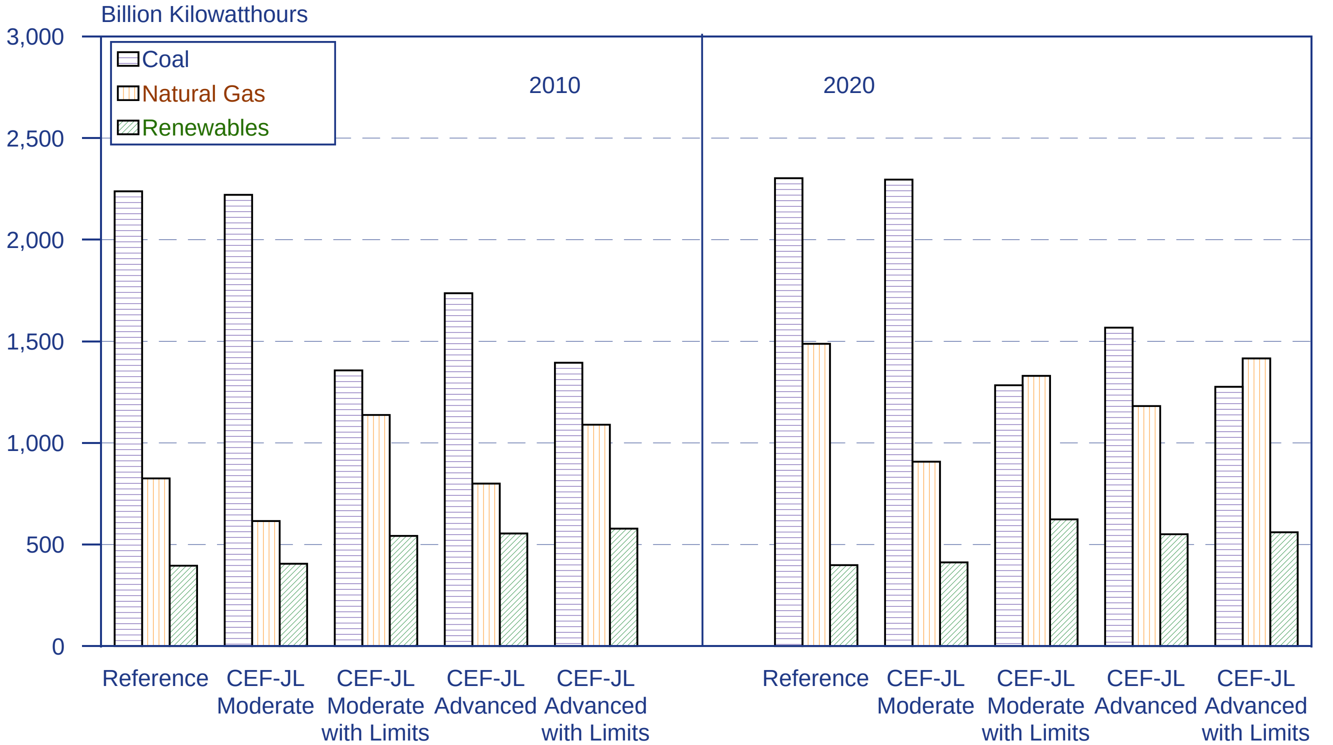


Source: National Energy Modeling System, runs SCENCBS.D080301A, SCENCEM.D081601A, SCENDBS.D092601B, and SCENDEMR.D092701A.

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	2007 *CEF-JL* Moderate: Without Emissions Limits	2007 *CEF-JL* Moderate: With Emissions Limits	2007 *CEF-JL* Advanced: Without Emissions Limits	2007 *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.