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.