Executive Summary

This analysis responds to a request from Senators Smith, Voinovich, and Brownback to examine the costs of specific multi-emission reduction strategies in the electricity generation sector (see Appendix A for the requesting letter). In their request, Senators Smith, Voinovich, and Brownback asked the Energy Information Administration (EIA) to analyze the impacts of three scenarios with alternative power sector emission caps on nitrogen oxides (NO_x), sulfur dioxide (SO_2) and mercury (Hg). They also requested an analysis of the potential costs of requiring power suppliers to acquire offsets for any increase in carbon dioxide (CO_2) emissions that occur beyond the level expected in 2008.

Specifically, EIA was asked to analyze the following three scenarios for reducing power sector emissions with and without holding CO_2 emissions to 2008 reference case levels:

- **Scenario 1:** Reduce NO_x emissions by 75 percent below 1997 levels, SO_2 emissions by 75 percent below full implementation of Title IV of the Clean Air Act Amendments of 1990 (CAAA90), and Hg emissions by 75 percent below 1999 levels by 2012, with half the reductions for each of the emissions occurring by 2007.
- **Scenario 2:** Reduce NO_x emissions by 65 percent below 1997 levels, SO_2 emissions by 65 percent below full implementation of Title IV of the CAAA90, and Hg emissions by 65 percent below 1999 levels by 2012, with half the reductions occurring by 2007.
- **Scenario 3:** Reduce NO_x emissions by 50 percent below 1997 levels, SO_2 emissions by 50 percent below full implementation of Title IV of the CAAA90, and Hg emissions by 50 percent below 1999 levels, with half the reductions occurring by 2007.

The emissions reduction programs are assumed to cover all power generators other than industrial cogenerators and are patterned after the SO_2 allowance trading program created in the CAAA90. For Hg the Senators specified that half the reductions required in each scenario are to come from site-specific reductions. The specific emission caps imposed in each case are given in Table ES1.

The key results of controlling NO_x, SO_2, and Hg to the required levels include:

- Adding emissions control equipment to reduce NO_x, SO_2, and Hg is projected to be the dominant compliance option (Table ES2). The values in Table ES2 indicate that emissions control equipment is expected to be added to many of the existing U.S. coal-fired electric power plants, which currently total just over 300 gigawatts of capacity. The percentage of existing coal-fired capacity expected to have SO_2 scrubbers is larger than suggested by the values shown in Table ES2, because 90 gigawatts of that capacity already is equipped with scrubbers.
- Decreased use of coal and increased use of natural gas in the electricity sector is projected to result when emission reduction efforts of these levels are required. By 2020, coal-fired electricity generation is projected to be between 4 percent and 10 percent below the reference case level, and natural-gas-fired generation is projected to be between 4 percent and 10 percent above the reference case level (Table ES3).
- The potential for emission "leakage" outside the electricity generation sector is slight,[1] because coal plays such a small role in the residential, commercial, and industrial sectors and because the higher natural gas prices that result from increased use of natural gas in the generation sector lead to lower overall fuel consumption and lower emissions in the non-electricity sectors.

Table ES1. Emission Reduction Targets in the Analysis Cases

Emissions	Base Level for Reductions[a]	Reduction Targets		
		50-Percent Reduction Case	65-Percent Reduction Case	75-Percent Reduction Case
NO_x (Thousand Tons)	6,191	3,096	2,167	1,548
SO_2 (Thousand Tons)	8,950	4,475	3,133	2,238
Hg (Tons)	43	22	15	11

[a]The base level for NO_x is 1997 emissions. For SO_2 it is the final target in the Clean Air Act Amendments of 1990. For Hg it is estimated 1999 emissions.

Source: Analysis request letter (see Appendix A).

[1]Emission leakage occurs when control programs in a sector that is covered lead to actions that increase emissions in sectors not covered by the programs.

- Emission allowance costs and electricity prices are projected to increase as the caps on NO_x, SO_2, and Hg are tightened across the cases. The price of electricity is projected to be between 1 percent and 6 percent higher in 2020 than in the reference case. The Nation's total electricity bill (in 1999 dollars) is projected to be between $3 billion and $13 billion (1 to 5 percent) higher in 2020 than projected in the reference case.

- Over the 2001 to 2020 forecast period, power supplier resource costs (in 1999 dollars) are projected to be between $28 billion and $89 billion higher than in the reference case.

- If power suppliers were required to purchase offsets for CO_2 emissions above the level projected to be emitted in 2008 in the reference case, they would need to purchase between 65 million and 89 million metric tons of offsets in 2020. There is considerable uncertainty about the potenial price of carbon offsets in world markets, and EIA has not performed any analysis in this area; however, using information from the Pacific Northwest Laboratory's Second Generation Model (SGM) and assuming that the United States would not participate in the Kyoto Protocol, it appears that full worldwide trading of energy-related carbon offsets would lead to a price of about $10 per ton. At that price, the cost of purchasing offsets in the three cases would range between $654 million and $888 million in 2020, or roughly 0.3 to 0.4 percent of the industry's projected revenue in 2020. If trading programs also include offsets from reductions in emissions of other greenhouse gases (such as methane) or investments in "carbon sinks" (such as reforestation programs)—which are not analyzed in this report—the costs could be lower.

- As in any 20-year projection, these results include numerous uncertainties. Key uncertainties include the following:

  – **Future natural gas prices.** Higher natural gas prices than those projected in this report would increase the costs of reducing power sector emissions.

  – **Cost and performance of new emissions control equipment.** Because few full-scale tests have been conducted, there is significant uncertainty about the cost and performance of Hg control equipment. In addition, the impact of equipment designed to remove NO_x and SO_2 on Hg emissions is also uncertain at this time.

Table ES2. Projected Additions of Emissions Control Equipment, 1999-2020
(Gigawatts)

	Cumulative Capacity Adding Controls				
Analysis Case	SO_2 Scrubber	Selective Catalytic Reduction (SCR)	Selective Noncatalytic Reduction (SNCR)	Hg Fabric Filter	Hg Spray Cooler
Reference	17.5	91.1	46.0	0.0	0.0
50-Percent Reduction	90.0	98.0	14.6	45.5	1.6
65-Percent Reduction	127.3	156.3	55.5	60.5	3.8
75-Percent Reduction	151.5	218.1	43.8	66.9	29.3

Note: The reference case assumes a 19-State summer season NO_x program beginning in 2004. The analysis cases assume the proposed annual programs without the summer limits. SCRs and SNCRs are NO_x removal technologies.
Source: National Energy Modeling System, runs SCENABS.D080301A (Reference), RENC5012.D081701B (50-Percent Reduction), RENC6512.D081701B (65-Percent Reduction), and RENC75.D081701B (75-Percent Reduction).

Table ES3. Key Projections in the Analysis Cases, 2020

Analysis Case	SO_2 Allowance Price (1999 Dollars per Ton)	NO_x Allowance Price: Annual (1999 Dollars per Ton)	NO_x Allowance Price: Seasonal (1999 Dollars per Ton)	Hg Allowance Price (1999 Dollars per Pound)	Electricity Price (1999 Cents per Kilowatthour)	Electricity Sales (Billion Kilowatthours)	Electricity Industry Revenues (Billion 1999 Dollars)
Reference	200	0	5,087	0	6.13	4,763	292
50-Percent Reduction	719	1,108	0	21,119	6.22	4,749	295
65-Percent Reduction	1,390	1,457	0	41,190	6.35	4,736	301
75-Percent Reduction	1,737	2,825	0	85,225	6.48	4,716	305

Note: The reference case assumes a 19-State summer season NO_x program beginning in 2004. The analysis cases assume the proposed annual programs without the summer limits.
Source: National Energy Modeling System, runs SCENABS.D080301A (Reference), RENC5012.D081701B (50-Percent Reduction), RENC6512.D081701B (65-Percent Reduction), and RENC75.D081701B (75-Percent Reduction).

– **The changing structure of U.S. electricity markets.** This study assumes that wholesale power markets in the U.S. will behave competitively. If they do not, compliance costs could be higher.

– **The policy instrument used to reduce power plant emissions.** This study assumes that an efficient cap and trade system will be set up to reduce power plant emissions. Numerous other policy instruments—such as taxes, technical standards, or a generation performance standard with cap and trade—are available. If an alternative instrument were used, the compliance costs and price impacts would be different from those projected in this analysis.