M.J. Bradley & Associates, Inc. ■ June 2008

Coal and Natural Gas Use in the Electric Power Sector under the Climate Security Act

Analysis of the Climate Security Act of 2008 shows that it is feasible to deploy energy efficiency, renewable energy, and other low-carbon technologies at a rate that enables the bill's emission reduction targets to be achieved without disruptive fuel-switching to natural gas. While not a prediction of the future, this report presents a scenario where increased reliance on efficiency, renewable resources like wind, solar, and biomass, and carbon dioxide capture from coal power plants can achieve the near and mid-term reduction goals of the Climate Security Act without significant changes in reliance on coal, natural gas or nuclear energy to meet U.S. power needs.

The Climate Security Act of 2008 ("CSA") has emerged as the leading legislative proposal for regulating U.S. greenhouse gas emissions since it was successfully voted out of the Senate Environment and Public Works Committee in December 2007 and now moves to the Senate floor. The bill would regulate U.S. greenhouse gas emissions by establishing a comprehensive national "cap-and-trade" system, and ultimately seeks to eliminate 70 percent of U.S. greenhouse gas emissions by mid-century.

Since the release of the bill, the U.S. Energy Information Administration (EIA), U.S. Environmental Protection Agency (EPA), and several private consulting firms and academic institutions have conducted economic modeling of the CSA in an effort to understand the potential impacts of the bill on energy prices, capital investment decisions, gross domestic product, and future emissions levels.[1] The bill has been evaluated using the ADAGE model,

This paper was prepared by M. J. Bradley & Associates, Inc. on behalf of the Natural Resources Defense Council (NRDC). M. J. Bradley & Associates is a private energy and environmental consulting firm based in Concord, Massachusetts.

[1] The three analyses discussed in this report were conducted on the version of the Climate Security Act as reported in December 2007 from the Senate Environment and Public Works Committee (i.e., S. 2191). Changes made by the Boxer-Lieberman-Warner substitute (S. 3036) to the reported bill are not expected to alter the results discussed in this report.

IGEM model, MARKAL model, NEMS model, IPM model, as well as others, using a variety of input assumptions. This report synthesizes the results of several of these studies, focusing in particular on the projected impacts of the CSA on coal and natural gas use in the electric power sector.

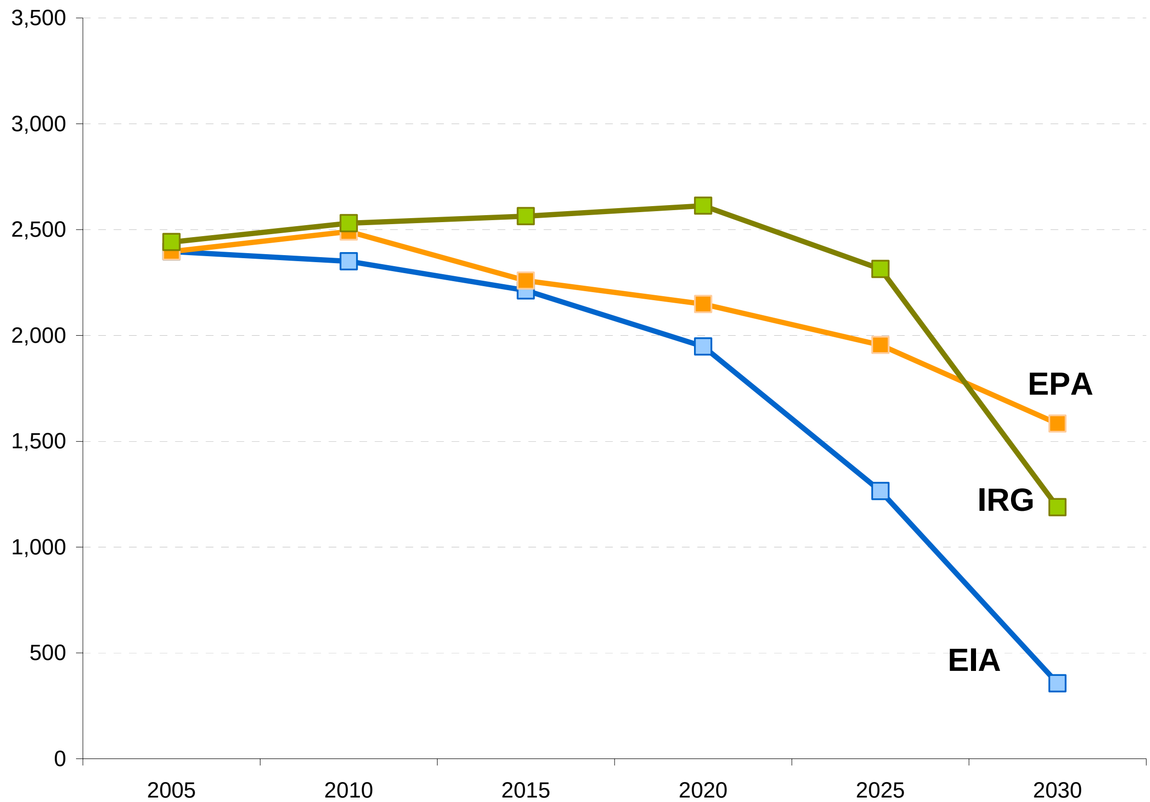
This report also presents a composite scenario that would achieve the CSA emission targets with coal and natural gas use unchanged from current levels.[2] In the composite scenario, energy efficiency, renewable energy and use of carbon dioxide capture and storage (CCS) are assumed to be employed at greater than historic rates in response to the requirements and incentives in the CSA. The analysis shows that the increases in energy efficiency, renewable energy and CCS deployment assumed in the composite scenario are within the range of penetration rates for other energy resources.

Key Drivers of Power Generation Fuel Choice in Models

Forecasts of changes in power generation fuel mix are driven by estimates of the share of total emission reductions that will occur in the power sector and by assumptions about the cost, performance, and availability of various electric generating technologies. Figure 1 plots the estimated CO_2 emissions reductions in the electric power sector under the CSA, according to model runs generated by EIA, EPA, and the International Resources Group (for a study commissioned by the Natural Resources Defense Council). As indicated by Figure 1, different analyses forecast significantly different emission paths for the power sector under the CSA and these differences become much larger after 2025. As discussed below, because of this uncertainty about the period beyond 2025, this report focuses on changes in the power sector through 2025, which is the timeframe that has been the focus of greatest attention regarding the issue of coal and natural gas use in the sector.

[2] Whether such a scenario is an “optimum” one from an economic, environmental, or energy security standpoint is beyond the purpose of this report. The purpose here is simply to show one example of how both the CSA emission caps and future electricity demand can be met without *requiring* a significant change in the use of coal, natural gas or nuclear energy in the power sector.

Figure 1. Electric Power Sector CO_2 Emissions (million metric tons CO_2)
Assessments by EIA, EPA, and IRG suggest that emissions reductions in the electric power sector will be modest through 2015 relative to current emissions levels.
Source: EIA S. 2191 Core, EPA S. 2191 IPM High Technology Scenario, IRG S. 2191 Case A



Coal is the most carbon intensive of the fossil fuels used in electricity production. A typical coal-fired power plant will produce about one ton of CO_2 for every megawatt hour of electricity that it generates, while a natural gas-fired power plant will produce about one-half ton of CO_2 per megawatt hour. The high carbon intensity of coal raises concerns among some analysts that requirements for large reductions in CO_2 emissions before 2025 could result in substantial fuel switching in the electric power sector from coal to natural gas. Such fuel switching, absent commensurate increases in gas supply, could impact both electricity prices and the price of natural gas in the residential, commercial, and industrial sectors as demand for natural gas increases. However, as discussed later in this paper, this generally only occurs in analyses that assume other electric generating technologies are sharply limited and when energy efficiency is assumed to play a limited role.

EIA, EPA, and IRG provide model results out to 2030 (and beyond, in some cases); however, for the purposes of this paper, we focus on the modeling results through 2025. Attempting to forecast future technology costs, energy prices, and the response of households and businesses to a carbon price signal 20 or 30 years into the future is obviously fraught with uncertainty. Beyond that, however, EPA specifically advises against using the final year results projected by its IPM model and technology choices among the models diverge dramatically after 2025.[3] In the time horizon to 2025, the period where most concern about fuel switching has focused, we find more agreement among the models in terms of the impacts on coal use and natural gas use in the electric power sector.

Projections of Coal-Fired Power Generation

Given the assumptions regarding technology costs and performance included in their computer modeling studies, EIA, EPA, and IRG show results ranging from slight increases to moderate reductions in coal-fired power generation in 2025 compared to current levels, with the CSA in place.[4,5] EPA's analysis of the bill forecasts that coal-fired power generation declines 14 percent and 20 percent by 2020 and 2025, respectively, relative to forecasted 2010 levels. IRG's model run forecasts a 10 percent increase in coal-fired power generation by 2020, relative to 2010 levels, and a 5 percent increase above 2010 levels by 2025. EIA's analysis forecasts both the largest overall reductions in power sector emissions and the largest reduction in coal-fired power generation. According to EIA's analysis, coal-fired power generation declines 8 percent and 29 percent by 2020 and 2025, respectively, relative to 2010 levels. EIA's analysis also forecasts a large increase in nuclear power generation over the same time period (118 GW of new nuclear power capacity by 2025).

---

[3] For example, EIA projects that 145 GW of new nuclear power capacity will be added between 2025 and 2030, while IRG projects no growth in nuclear power capacity during this period.

[4] For an overview of the model runs used in this analysis, see the descriptions at the end of this paper.

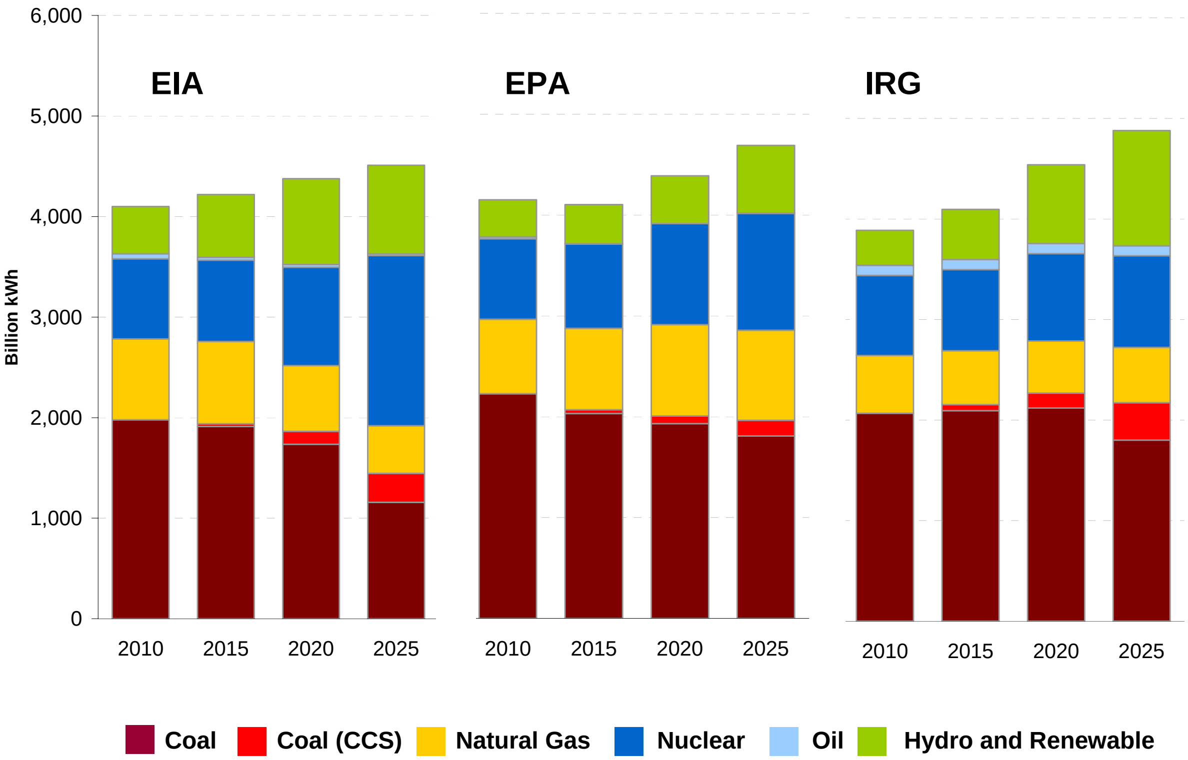
[5] Beyond 2025, the share of coal and natural gas use for electric power production drops significantly in some of the analyses depending on long term assumptions of costs and performance of different generation technologies. EIA, for example, assumes that it will be possible to construct a large amount of new nuclear capacity by 2030 at relatively low cost. This reduces coal generation to about 35% of projected 2010 levels. Because of the high degree of uncertainty underlying these assumptions, we consider these results to be less reliable.

Figure 2 summarizes the projections of electricity generation by fuel type in the EIA, EPA, and IRG model runs.

Figure 2. Electricity Production by Fuel Type

Assessments by EIA, EPA, and IRG suggest that coal-fired power generation will change slightly to moderately in 2025 under the CSA, compared to forecasted 2010 levels. Prices reported in 2006 dollars per short ton.

Source: EIA S. 2191 Core, EPA S. 2191 IPM High Technology Scenario, IRG Case A



Business-as-usual model runs—runs assuming no federal limits on greenhouse gas emissions—generally forecast significant increases in coal-fired power generation[6] (and CO_2 emissions) as demand for electricity rises, while studies of the CSA forecast increased reliance on a combination of lower-emitting resources, including renewable energy, nuclear power, and demand-reduction measures. EPA's analysis forecasts that with CSA enacted, most of the

[6] Although EIA, in its most recent analysis of the CSA, notes that such increases in coal generation may not occur given the growing concern in the financial community about the viability of new coal projects amid the increasing concern about such projects' high CO_2 emissions. U.S. Energy Information Administration, Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007, April 2008 (page xiii).

existing fleet of coal-fired power plants would continue to operate through 2025 under the bill. EPA's analysis of the CSA forecasts the retirement of 47 gigawatts (GW) of coal-fired generating capacity by 2025 and the addition of 21 GWs of new coal capacity with carbon capture and sequestration technology over the same time frame.[7] There are currently 330 gigawatts of coal-fired generating capacity in the U.S.

Composite Scenario

The different computer model studies featured in this report forecast different emission paths for the power sector under the CSA through 2025. Here we examine the implications of achieving a 20 percent reduction in electric sector CO_2 emissions by 2025 from current levels. This is more aggressive than the EPA and IRG forecasts, but less aggressive than the EIA analysis. In a composite scenario we illustrate the amount of non-emitting electric generating capacity (or energy efficiency savings) that would be needed by 2025 to achieve this reduction in CO_2 emissions and meet EIA's projection of future electricity demand without significant changes in coal and natural gas consumption in the electric power sector from current levels.[8]

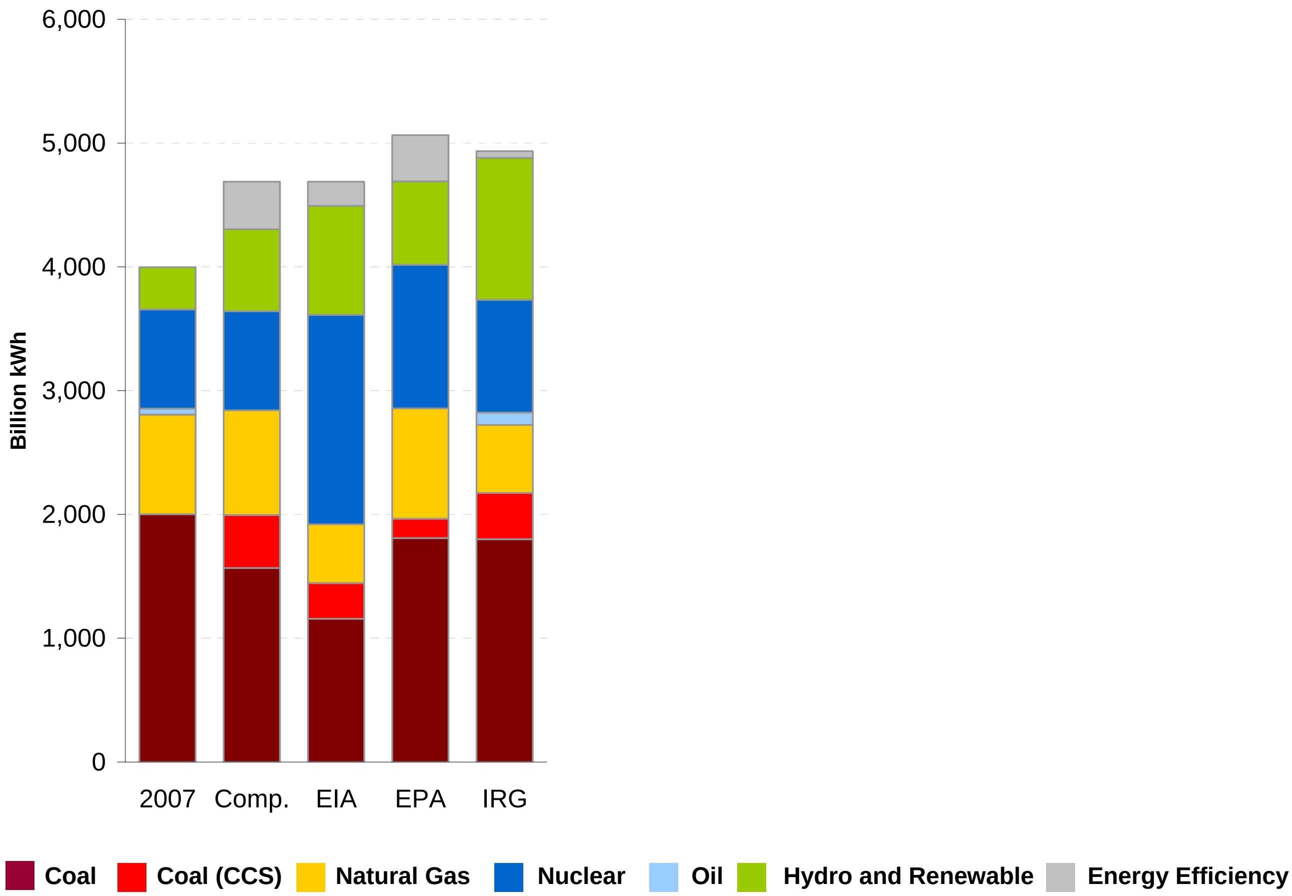
In our composite scenario, CO_2 reductions are achieved by employing energy efficiency to reduce demand, accelerating reliance on renewable energy resources, by constructing approximately 65 gigawatts of coal capacity with carbon capture and storage technology by 2025, and improving the average efficiency of natural gas use in the electric power sector by 5 percent. The scenario assumes nuclear generation remains at current levels through 2025. The final generation fuel mix is summarized in Figure 3 for the composite scenario as well as the EIA, EPA, and IRG scenarios in 2025.

[7] Based on EPA's S. 2191 IPM High Technology Scenario. According to EPA, this scenario approximates EIA's current updated Annual Energy Outlook, including the provisions the Energy Independence and Security Act of 2007, which was adopted after EPA completed its modeling.

[8] Coal consumption is maintained at 20,679,040,909 mmBtu and natural gas consumption is maintained at 6,965,758,801 mmBtu (consistent with the values reported in EIA's AEO 2008 for 2007).

Figure 3. Electricity Production by Fuel Type in 2025 (compared to 2007)

Through a combination of technologies, 20% of electric power sector CO_2 emissions could be eliminated without significant changes in amounts of coal and natural gas generation.
Source: EIA S. 2191 Core, EPA S. 2191 IPM High Technology Scenario, IRG Case A



These technology deployment rates in the composite scenario appear to be achievable given past rates of capital deployment in the electric power sector and the incentives provided by the CSA for the deployment of energy efficiency, renewable energy, and carbon capture and storage technologies.

- Deploying 65 gigawatts of coal capacity with carbon capture and storage technology by 2025 will require an average of six gigawatts of new capacity each year between 2015 and 2025. In the period from 1960 to 1980, the electric power sector added an average of 9.8 gigawatts of new coal-fired generating capacity each year, and from 2000 to 2006, the sector added an average of 34.7 gigawatts of natural gas-fired generating capacity.

Additionally, between 2012 and 2025, the CSA provides at least $70.5 billion in cumulative allowance value for the development and deployment of carbon capture and storage technologies.[9] This incentive would cover a large share of the total capital costs of the 65 gigawatts of new coal capacity with carbon capture and storage technology in this scenario based on recent cost estimates developed by the Department of Energy.[10]

- In 2025, the CSA allocates 9.75% of its allowance value to local electric distribution companies. Assuming that 50% of this allowance value is dedicated to energy efficiency programs, this translates to roughly $8 billion in funding for utility energy efficiency programs in 2025 alone.[11] For the purpose of this analysis, we assume a price of $40 per megawatt hour for energy efficiency savings, although several technologies can deliver savings below this price.[12] This translates to a saving of 207,311 gigawatt hours.

- EIA projects a seven to nine percent efficiency improvement in the use of natural gas in the electric power sector from 2012 to 2025 from increased reliance on high efficiency combined-cycle technology.[13] For the purposes of this analysis, we assume a five percent efficiency improvement.

- The composite scenario requires about 300,000 gigawatt hours of new renewable energy generation by 2025, or an average of 23,000 gigawatt hours of additional renewable energy generation each year from 2012 to 2025. Between 2005 and 2006, renewable energy generation increased by 9,239 gigawatt hours, falling short of the pace required to meet the goals of the composite scenario. However, the CSA dedicates more than $100 billion in allowance value to the development and deployment of renewable energy technologies from 2012 to 2025. Also, the U.S. Department of Energy has concluded that wind energy

[9] Calculated based on allowance prices from EIA's S. 2191 Core Case.
[10] U.S. Department of Energy, Cost and Performance Baseline for Fossil Energy Plants, Revision 1, August 2007.
[11] The allowances allocated to local distribution companies can also be used for consumer rebates. The allowance value was calculated based on a price of $39 per metric ton, as forecast in EIA's S. 2191 Core Case.
[12] http://www.dora.state.co.us/puc/projects/NewEnergy/PathForward/PF10-30-07HGeller-SWEEP_CostEffective.pdf
[13] EIA, S. 2191 Core Case, Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007.

could produce 20 percent of U.S. electricity by 2030 (1,160,000 gigawatt hours).[14] This would be more than enough renewable energy generation to meet the goals of the composite scenario.

Projections of Natural Gas-Fired Generation

Like the projections of coal-fired power generation, EIA, EPA, and IRG forecast a range of outcomes in terms of natural gas-fired power generation; however, their results generally fall within a reasonable range of recent levels. IRG forecasts a modest decline in natural gas-fired generation by 2020 and 2025: 15 percent and 10 percent, respectively, from projected 2010 levels (business-as-usual forecast). EIA forecasts a more significant decline in natural gas-fired generation by 2020 and 2025: 20 percent and 42 percent, respectively. (EIA's S. 2191 Limited Alternatives case projects a 21 percent increase in natural gas-fired power generation by 2020 and a 48 percent increase by 2025, assuming that no carbon capture and storage technology is available until after 2030 and that increases in renewable and nuclear generation are also constrained.) In contrast, EPA forecasts an increase in natural gas-fired generation. EPA forecasts about a 25 percent increase in natural gas-fired power generation by 2020 and 2025 from projected 2010 levels (Reference Case).

In terms of natural gas prices for the electricity sector, all three models forecast natural gas prices under the CSA at levels similar to their business-as-usual projections through 2030. EIA forecasts prices declining from about $7.00 per thousand cubic feet in 2010 to $6.00 per thousand cubic feet in 2025 (excluding the cost of allowances). IRG forecasts prices ranging from about $8.00 per thousand cubic feet in 2010 to $9.00 per thousand cubic feet in 2025 (excluding the cost of allowances). EPA forecasts prices below $7.00 per thousand cubic feet through 2025 (excluding the cost of allowances). To put these figures in perspective, EIA reports recent natural gas prices in the U.S. ranging from $8.47 per thousand cubic feet in 2005 to $7.30 per thousand cubic feet in 2007 (delivered prices to electric power producers).

[14] U.S. Department of Energy, 20% Wind Energy by 2030 Increasing Wind Energy's Contribution to U.S. Electricity Supply, DOE/GO-102008-2567, May 2008.

The CSA would require natural gas processors and natural gas importers to surrender allowances based on the quantities of natural gas sold. These incremental costs would be substantially mitigated through the free distribution of allowances. The CSA distributes free allowances to natural gas local distribution companies, natural gas processors, power plants consuming natural gas, and industrial facilities combusting natural gas.

In conclusion, this analysis finds that the CSA emission reduction targets for 2025 can be achieved without causing disruptive fuel-switching or radical natural gas price increases. Specifically:

- A composite scenario for the electric sector shows that a 20 percent reduction in electric sector CO_2 emissions by 2025 could be achieved, without significant change in generation from coal, natural gas, and nuclear power compared to current levels, by deploying energy efficiency, renewable energy, and carbon capture and storage at rates that appear reasonable based on both historical experience and the effect of the incentives for these technologies provided by the CSA. This scenario differs somewhat from computer-based modeling analyses but employs reasonable rates of deployment for lower-emitting electricity resources.
- The three computer model studies suggest modest emissions reductions in the electric power sector in the initial years. EIA and EPA modeling estimate emissions reductions of 6 percent and 9 percent in 2015, while IRG estimates a 1 percent increase. In 2025, EIA, EPA, and IRG estimate emissions reductions of 46 percent, 22 percent, and 9 percent, respectively.
- The three models also suggest moderate changes in coal-fired power generation through 2025. The analyses suggest that under the CSA, coal-fired power generation could remain between 5 percent above and 29 percent below forecast 2010 levels in 2025.
- Forecasts for natural gas generation show a similar pattern, with model results varying but generally predicting moderate changes in generation compared to current levels, except when alternative resources are assumed to be constrained. Under the CSA, the computer-based studies indicate natural gas-fired generation could remain between 25 percent above and 42 percent below forecast 2010 levels through 2025.

- Natural gas prices (excluding allowance costs) are expected to be comparable to or less than business-as-usual scenarios through 2030.
- Studies of the CSA forecast increased reliance on a combination of energy efficiency programs and a variety of zero- and low-carbon electric power resources. Only when all or most of these alternatives are assumed to be substantially limited are coal and natural gas generation significantly affected.

Overview of Modeling Scenarios

EIA's S. 2191 Core Case is EIA's primary S. 2191 policy case. The scenario was modeled using NEMS and is based on the AEO2008 Reference Case assumptions. The scenario assumes no major obstacles to the deployment of key low-emissions technologies, including nuclear, fossil with carbon capture and sequestration (CCS), and renewables, and the use of offsets, both domestic and international, is not significantly limited by cost or regulation.

EPA's S. 2191 IPM High Technology Scenario is directionally similar to forthcoming model runs that EPA is preparing incorporating the AEO 2008 assumptions including incentives and standards of the Energy Independence and Security Act of 2007, which was adopted after EPA completed its modeling. EPA relied on CO2 allowance price projections from the ADAGE model in preparing its IPM model runs.

IRG's S. 2191 Case A was performed using an improved and extended version of the US national MARKAL model (US-NM50) originally developed by the Environmental Protection Agency's Office of Research and Development. Case A illustrates a future where substantial reductions in renewable energy costs occur as experience with these technologies accumulates, causing those resources to achieve a large market share after 2030.