National Commission on Energy Policy

Economic Analysis of Updated Commission Recommendations

June 2007

Introduction

This appendix describes the results of a modeling analysis undertaken to assess the economic and emissions impacts of updated recommendations issued by the National Commission on Energy Policy in April 2007. Those recommendations sought to accelerate progress in areas where the Commission believes current energy-policy initiatives remain inadequate to the challenges at hand, particularly with respect to oil security and climate change. Specifically, the Commission has recently proposed to strengthen key parameters of the mandatory, economy-wide greenhouse-gas trading program first proposed in its 2004 report, *Ending the Energy Stalemate*, and has recommended a package of supplementary policies to improve vehicle fuel economy, promote energy efficiency, boost incentives for carbon capture and storage, and increase the renewable-energy contribution to the nation's electricity supply.

To analyze the combined impact of these recommendations, the Commission used the National Energy Modeling System (NEMS), a detailed model of energy production and consumption used by the U.S. Energy Information Administration (EIA) to develop forecasts and assess policy options.[1] The Commission was interested in using this tool to estimate benefits, costs, and sectoral impacts under different program parameters and in exploring how technology- and sector-oriented policies might interact with a broad-based greenhouse-gas price signal. Thus, in addition to assessing effects on emissions, energy prices, and GDP, the modeling analysis was undertaken to answer questions such as:

- Is it possible to strengthen the Commission's original (2004) proposal for a mandatory, greenhouse-gas trading program without causing harm to the broad economy?
- Under what circumstances is the safety valve in the NCEP recommendations likely to be triggered?
- What assumptions or policies play a particularly important role in enabling emission-reduction targets to be met at an acceptable cost in terms of energy-price and GDP impacts?
- Is the combination of a carbon dioxide (CO_2) price and direct technology incentives adequate to speed the development and deployment of carbon capture and storage technology in the power sector?
- What is the interaction between a CO_2 price and a national renewable portfolio standard in expanding the future contribution of renewable energy sources?

[1] A detailed description of the NEMS model can be found at http://www.eia.doe.gov/oiaf/aeo/overview/index.html. The model was used to forecast impacts to 2030, consistent with the forecasting period used in EIA's Annual Energy Outlook.

In general, the results of the analysis underscore the importance of underlying technology assumptions in driving projections of economic cost and environmental benefit under different policy scenarios. With relatively optimistic technology assumptions—concerning, for example, the potential for energy-efficiency improvements in the transportation and buildings sectors, and the deployment of new technologies like carbon capture and storage—the emission reductions stimulated by a given greenhouse-gas price signal as much as double. Conversely, with less favorable technology assumptions, the price signal required to achieve a given environmental target becomes substantially higher.

The overall results of the modeling analysis provide, in our view, considerable grounds for optimism concerning the feasibility and affordability of undertaking a major shift in the nation's energy trajectory over the next two decades, *provided* the political will exists to implement a well-designed and comprehensive package of policies within the next few years. Specifically, the Commission's findings suggest that the combination of a meaningful price signal for reducing greenhouse-gas emissions and effective technology policies can achieve substantial reductions in greenhouse-gas emissions across all sectors of the economy without triggering the proposed safety-valve mechanism and without incurring significant energy price shocks or GDP losses—and do so while simultaneously preserving a major role for coal, reducing oil dependence, and substantially boosting the contribution of clean, domestic renewable resources. Substantial improvements in vehicle fuel economy and end-use efficiency throughout the industrial, residential, and commercial sectors also play a critical role in achieving this result.

The remainder of this appendix describes the results of the Commission's recent modeling efforts in detail—including providing answers to the above-identified questions. Before proceeding to results, however, it is useful to begin by reviewing the parameters and limitations of the analysis.

Updated Commission Recommendations and Key Modeling Assumptions

Table 1 summarizes the key assumptions used in the modeling analysis to reflect the Commission's updated recommendations concerning the design of a mandatory, greenhouse gas trading program and other policies to improve oil security, assure ample and reliable energy supplies, and overcome market hurdles to the deployment of new, low-carbon energy technologies. It is worth noting that some elements of the Commission's larger package of updated recommendations could not be readily modeled within the NEMS framework and thus are not included in the analysis. For example, the Commission did not model its recommendations to address hurdles to further biofuels deployment. Results of the analysis are presented, throughout the discussion that follows, as changes relative to the EIA's Annual Energy Outlook 2006 business-as-usual reference-case forecast, which includes policy changes introduced under the Energy Policy Act of 2005 (EPAct05).

Table 1: Key Modeling Assumptions Used to Analyze Updated NCEP Recommendations

Vehicle Fuel Economy	Average combined new car and light-truck fuel economy increases gradually to reach 41 miles per gallon by 2030. This is just slightly below the Commission's current recommendation for a presumptive 4 percent per year (approx. 1 mpg per year) rate of improvement in average light-duty vehicle fuel economy.
Climate Change	Mandatory economy-wide greenhouse gas trading program implemented in 2012 with the following features: • Annual program targets defined to achieve stabilization of emissions at 2006 levels by 2020 and 15% reduction below 2006 levels by 2030. • "Safety valve" price starts at $10 per ton CO_2-equivalent in 2012 and escalates 5% per year in real terms thereafter.
Energy Efficiency	Uses assumptions in EIA's "High Technology" side case from the Annual Energy Outlook 2006 for the residential, commercial, industrial, and transportation sectors. This case is used to reflect the effects of technology improvements resulting from the Commission's updated energy efficiency and RD&D recommendations (see further discussion in main text).
Advanced Coal	Carbon capture and storage projects receive production incentives similar to the renewable production tax credit.
Renewable Electricity	A federal renewable portfolio standard is adopted to increase the nation's share of renewable electricity sales to at least 15% by 2020. Consistent with past legislative proposals, the standard includes a 1.5 cent price cap on the cost of renewable energy credits. (Note that the Commission has not made any recommendations concerning the inclusion of a price cap in a national RPS.)
Technology RD&D	Uses EIA's "High Technology" side case from the Annual Energy Outlook 2006 for the electric sector (which includes high technology assumptions for fossil-fuel, nuclear, and renewable energy systems). This case is used to reflect the effects of technology improvements resulting from the Commission's updated RD&D recommendations.

As indicated in Table 1, the Commission's recommendations with regard to energy efficiency, expanded technology RD&D, and bonus allowances for carbon capture and storage were not modeled directly, but were instead represented using proxy assumptions. Whether these assumptions are more likely to understate or overstate the impact of Commission recommendations is difficult to assess. EIA's "High Technology" case, for example, assumes better than business-as-usual improvement in end-use efficiency in the residential and commercial sectors but is less aggressive than EIA's "Best Available Technology" case, which assumes that the most efficient equipment available in a given year is adopted regardless of cost (see text box on page XX). As such it represents an approximation rather than an effort to precisely estimate the savings likely to occur as a result of related Commission recommendations, which include extending and expanding federal tax incentives for efficiency improvements, issuing rigorous new appliance and equipment standards, and greatly increasing public expenditures on technology RD&D. In other respects, the modeling assumptions are clearly conservative: for example, they do not include additional policies—beyond those introduced in EPAct05—to boost the use of biofuels.

The Commission also analyzed two additional scenarios to elucidate the effects of the greenhouse gas trading program by itself (that is, without the additional or supplemental policies recommended by the Commission and summarized in Table 1) and to explore the impact of the safety valve in limiting economic costs under less favorable policy and technology assumptions. In one of these scenarios we model the effects of the proposed greenhouse gas trading program with no safety valve and no supplementary policies. In a second scenario, we assume the $10 safety valve is immediately triggered to simulate the maximum economic impact that would be expected if demand for emission allowances—in the absence of supplementary policies and/or with slower technology progress—causes allowance prices to rise to the Commission's proposed price cap.[2] Results from these scenarios are presented, along with results from the main analysis, in the discussion that follows.

Summary of Main Findings

The main findings of the modeling analysis are perhaps best summarized by returning to the questions posed at the outset of this discussion.

- Is it possible to strengthen the Commission's original (2004) proposal for a mandatory, greenhouse-gas trading program without causing harm to the broad economy?

The answer to this question is yes. The modeling analysis shows that the more stringent emissions-reduction targets in the Commission's 2007 proposal (i.e., stabilization at 2006 levels by 2020 and a 15 percent reduction below 2006 levels by 2030) can be achieved with impacts on GDP that range from the slightly positive to slightly negative but that are in all cases very small compared to expected growth in the nation's economy. Specifically, in the policy case—which includes the supplemental policy assumptions summarized in Table 1—improved technologies and reduced energy demand limit energy price impacts and produce a small *increase* in U.S. GDP. In other words, gains from efficiency improvements and better technologies are large enough to offset GDP losses resulting from the emission trading program (although it should be noted that economists are sometimes skeptical of analyses predicting economic gains from efficiency programs as there could be adjustment costs that are not adequately reflected in the modeling). As a result, overall GDP in 2030 is slightly (0.15 percent) higher in the policy case than in the reference case. Under less favorable technology and policy assumptions, the overall impact of the trading program on the nation's economic output turns slightly negative but remains below one half of 1 percent of projected GDP in 2030. While impacts on the broad economy are small, certain sectors, particularly coal mining and coal-consuming sectors, will

[2] The safety valve price is assumed to escalate at 5 percent per year above the rate of inflation.

face higher costs, as coal prices are expected to roughly double by 2030 as a result of the trading program.

- Under what circumstances is the safety valve in the NCEP recommendations likely to be triggered?

In the policy case, which includes substantial gains in vehicle fuel economy and end-use efficiency and the accelerated deployment of climate-friendly technologies, allowance prices are projected to remain below the safety valve throughout the forecast. Absent these favorable technology assumptions and supplemental policies, the safety valve in the NCEP recommendations is likely to be triggered in the early years of program implementation. This result suggests that adoption of the supplemental policies included in the Commission's updated package of recommendations is critical to achieving targeted greenhouse-gas reductions.

- What assumptions or policies play a particularly important role in enabling emission-reduction targets to be met by 2030 at an acceptable cost in terms of energy-price and GDP impacts?

As noted previously, improvements in vehicle fuel economy, enhanced end-use efficiency in the buildings and industrial sectors play an especially important role, although expanded deployment of advanced supply-side technologies—notably, carbon capture and storage and renewable energy—also make a significant contribution to achieving overall program goals. Stronger fuel-economy standards, in particular, are critical because the CO_2 price signal generated by the trading program alone would not be expected to produce substantial emission reductions from the transportation sector. With the level of vehicle efficiency improvement assumed in the policy case, the transport sector delivers roughly 16 percent of projected energy-related CO_2 reductions by 2030[3] and 1.2 billion barrels of oil savings per year by 2030.

Without significant transport-sector emissions reductions, on the other hand, a much larger share of the abatement burden falls to the electric power sector, which would be compelled to make commensurately larger investments in potentially more expensive options such as carbon capture and storage, new nuclear generation, and renewable energy. Technology improvements and associated end-use efficiency gains also play a crucial role *within* the electric sector where—as in the transportation sector—the modeling results suggest that the CO_2 price signal from the trading program would not be sufficient, by itself, to produce substantial demand reductions.

[3] See Figure 2 on page XX. Energy-related carbon emissions for purposes of this comparison do not include modeled reductions in non-CO_2 gases and reductions attributed to offsets.

- Is the combination of a CO_2 price and direct technology incentives adequate to speed the development and deployment of carbon capture and storage technology in the power sector?

Yes, modeling results for the policy case show significant capacity additions of advanced coal systems with carbon capture and storage (CCS) compared to the reference case. Specifically, 81,000 megawatts (MW) of coal capacity with CCS are added by 2030 in the policy case; as a result, coal consumption in 2030 is actually slightly higher (by 2 percent) than current consumption. By contrast, the reference case shows comparable capacity additions for advanced coal systems, but none of these additions include actual CCS. The modeling results further indicate that the CO_2 price signal alone accounts for a relatively small share of expected new CCS capacity by 2030. This finding underscores the importance of near-term policies aimed at directly supporting CCS technology, including production incentives and support for demonstration projects.

- What is the interaction between a CO_2 price and a national renewable portfolio standard in expanding the future contribution of renewable energy sources?

In the case of new renewable electricity technologies (primarily wind and biomass), the CO_2 price signal and a national renewable portfolio standard work together to produce a substantial increase in installed renewable generating capacity and electricity production. Specifically, the CO_2 price signal alone increases RPS-eligible renewable generation to approximately 12 percent of total electricity sales by 2030 compared to 2 percent in the reference case. Implementing a national renewable portfolio standard, as recommended in the Commission's updated proposal, results in further gains such that RPS-eligible renewable generation grows to 18 percent of overall sales by 2030. Importantly, the renewable contribution is limited, in the NEMS modeling runs, by a 1.5-cent price cap on the cost of renewable energy credits (where credits are assumed to be issued in per kilowatt-hour units). This constraint was included to reflect previous legislative proposals; it is not based on a Commission recommendation. With a higher price cap, the renewable contribution would be even higher under the policy case.

Economic (GDP) and Energy-Price Impacts

Table 2 shows the impact of the Commission's proposed package of policies on energy prices in 2020 and 2030, relative to EIA's reference-case forecast. In general, price impacts are relatively modest, ranging from a 3–7 percent increase in 2030 compared to the reference case, except in the case of coal where prices roughly double by 2030. Significant improvements in end-use efficiency and reduced electricity and natural gas demand, however, mitigate the impact of higher coal prices in the electric sector. As a result, electricity prices remain at roughly the same level as in the reference case through 2025 and rise only 5 percent above the reference case level by 2030.

Table 2: Summary of Energy Market Impacts[4]

	2005	2020		2030	
		AEO 2006 Reference	Policy Case	AEO 2006 Reference	Policy Case
Emissions of Greenhouse Gases (million metric tons CO_2-e)					
Energy-Related Carbon Dioxide	5,967	7,119	6,020	8,114	5,909
Other Covered Emissions	269	452	193	627	219
Total Greenhouse Gases	6,236	7,571	6,213	8,741	6,127
Emissions Reduction from Reference Case (million metric tons CO_2-e)					
Energy-Related Carbon Dioxide	-	-	1,099	-	2,206
Other Covered Emissions	-	-	259	-	409
Non-Energy Offset Credits	-	-	119	-	157
Carbon Sequestration	-	-	319	-	345
Total Emissions Reduction	-	-	1,478	-	2,771
Total (including sequestration)	-	-	1,797	-	3,116
Allowance Price (2004$ per metric ton CO_2-e)	-	-	$8.67	-	$19.60
Delivered Energy Prices (2004$ dollars per unit indicated) (includes allowance costs)					
Motor Gasoline (per gallon)	$2.31	$2.08	$2.04	$2.19	$2.26
Jet Fuel (per gallon)	$1.71	$1.42	$1.43	$1.56	$1.70
Distillate (per gallon)	$2.34	$2.03	$2.07	$2.14	$2.43
Natural Gas (per mcf)	$9.89	$7.14	$7.34	$8.22	$8.78
Residential	$12.68	$10.48	$10.56	$11.67	$12.20
Electric Power	$8.29	$5.53	$5.39	$6.41	$6.69
Coal, Electric Power (per million Btu)	$1.50	$1.39	$2.16	$1.51	$3.21
Electricity (cents per kilowatthour)	8.3 ¢	7.2 ¢	7.2 ¢	7.5 ¢	7.9 ¢
Fossil Energy Consumption (quadrillion Btu)					
Petroleum	40.2	48.1	42.8	53.6	44.6
Natural Gas	22.9	27.7	23.8	27.7	24.0
Coal	23.4	27.6	23.3	34.5	23.8
Electricity Generation (billion kilowatthours)					
Petroleum	115	107	40	115	38
Natural Gas	752	1,102	825	990	819
Coal	2,041	2,505	2,111	3,381	2,276
Nuclear	774	871	865	871	1,002
Conventional Hydropower	267	303	307	303	307
All Other Renewable	109	212	707	256	1,040
Total	4,058	5,099	4,855	5,915	5,482

[4] All 2005 data were sourced from the AEO 2006.

Additional analysis of the alternative scenarios noted above highlights the importance of supplemental policies and technology assumptions in driving model results. The full package of modeled policies achieves targeted emission reductions without triggering the Commission's recommended "safety valve" cap on allowance prices. *Absent* the improvements in vehicle fuel-economy, renewable energy production, and energy efficiency noted in Table 1, however, emissions in the electricity and transport sectors—and associated demand for allowances—are substantially higher. Achieving the same emission-reduction targets in this instance would entail significantly higher allowance costs and energy-price impacts. Specifically, the modeling analysis suggests that the Commission's recommended emissions targets alone—if imposed as a "hard" cap (that is, without a safety valve) and without additional policies—would result in allowance prices of roughly $23 per ton of CO_2 equivalent emissions in 2020 and nearly $50 per ton in 2030. Associated energy-price impacts would also be significantly larger: forecast prices for delivered natural gas, gasoline, and electricity would rise 29 percent, 19 percent, and 22 percent respectively above the reference case forecast by 2030, while coal prices would nearly quadruple.[5]

The existence of the safety valve would, of course, serve to limit price impacts under less favorable technology and policy conditions. To model the effects of this cost-containment mechanism, we assume that allowance prices—in the absence of supplemental policies and accelerated technology progress—reach the safety valve level in the early years of program implementation. In that case, energy-price and GDP impacts are slightly greater than those seen in the full policy case, but fall far short of the impacts seen under the hard-cap case. Specifically, at a safety-valve starting price of $10 per ton of CO_2-equivalent emissions, energy price increases for gasoline, delivered natural gas, and electricity range from 5 percent to 10 percent in 2020, and 8 percent to 15 percent in 2030. Coal prices rise by 83 percent in 2020 and 116 percent in 2030. Because energy expenditures account for only a small share of the overall economy, however, impacts on economic growth are considerably more modest. In 2030, GDP under the $10-per-ton safety-valve-only scenario is just 0.26 percent below projected GDP in the reference case. Cumulative GDP losses as a result of the emission trading program amount to 0.52 percent of cumulative GDP gains over the entire modeling period (2006–2030). In other words, GDP growth is reduced only slightly, from 100.8 percent to 100.2 percent between 2006 and 2030.[6]

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[5] Overall GDP impacts would also be higher than in the full policy case (a 0.46 percent reduction in forecast 2030 GDP compared to a 0.15 percent gain in the full policy case), though to a lesser degree in percentage terms than a simple comparison of energy-price impacts might suggest. This is because energy expenditures, though large in aggregate and certainly significant for many households and for certain industries, account for only a relatively small share of the nation's multi-trillion-dollar overall economy.

[6] This result includes economic benefits from the NEMS model's revenue-recycling assumptions. In addition to the economic impacts that result from changes in energy prices and resulting impacts on the production and consumption of energy-intensive goods and services, the model accounts for positive benefits associated with the auction and distribution of greenhouse-gas allowances. The distribution of allowances generates revenue streams to the government and private interests that are represented in the NEMS Macroeconomic Activity Module, which calculates aggregate impacts on prices, output, and employment within the economy. For this modeling exercise, assumptions concerning allowance allocation were taken from draft legislation sponsored by Senator Bingaman that is largely consistent with the NCEP proposal. The assumptions include $50 billion in cumulative RD&D

Table 3: GDP Impacts

	Reference Case	Policy Case	No Safety Valve	$10 Safety Valve
Annual GDP (Billions 2000$)				
2020	$17,541	$17,571	$17,499	$17,514
Percent change from Reference Case	-	0.17%	-0.24%	-0.15%
2030	$23,112	$23,148	$23,005	$23,052
Percent change from Reference Case	-	0.15%	-0.46%	-0.26%
Cumulative GDP Growth (Billions 2000$)				
2006-2030	$11,599	$11,633	$11,493	$11,540
Percent change from Reference Case	-	0.30%	-0.92%	-0.52%

Before concluding this section, it is important to stress again that the above-discussed results for safety-valve-only scenarios reflect relatively pessimistic technology and policy assumptions. That is, they assume the climate policy works entirely through the price signal generated by the greenhouse gas trading program *without* any additional benefits generated by supplemental policies or accelerated technology development in key areas like energy efficiency and carbon capture and storage.

Emission Impacts

The Commission's combined proposals result in significant greenhouse gas reductions compared to both current and forecast levels. Cumulative greenhouse gas emissions from covered sources[7] over the 2012–2030 period analyzed are 22 percent below reference-case emissions.[8] Allowance banking allows these emission reductions to be spread out over the forecast period, with regulated entities over-complying in the early years of program implementation when allowance prices are lower. Over 2,950 million metric tons of carbon-dioxide equivalent ($MMTCO_2e$) allowances are banked by 2022. Emissions then begin to rise

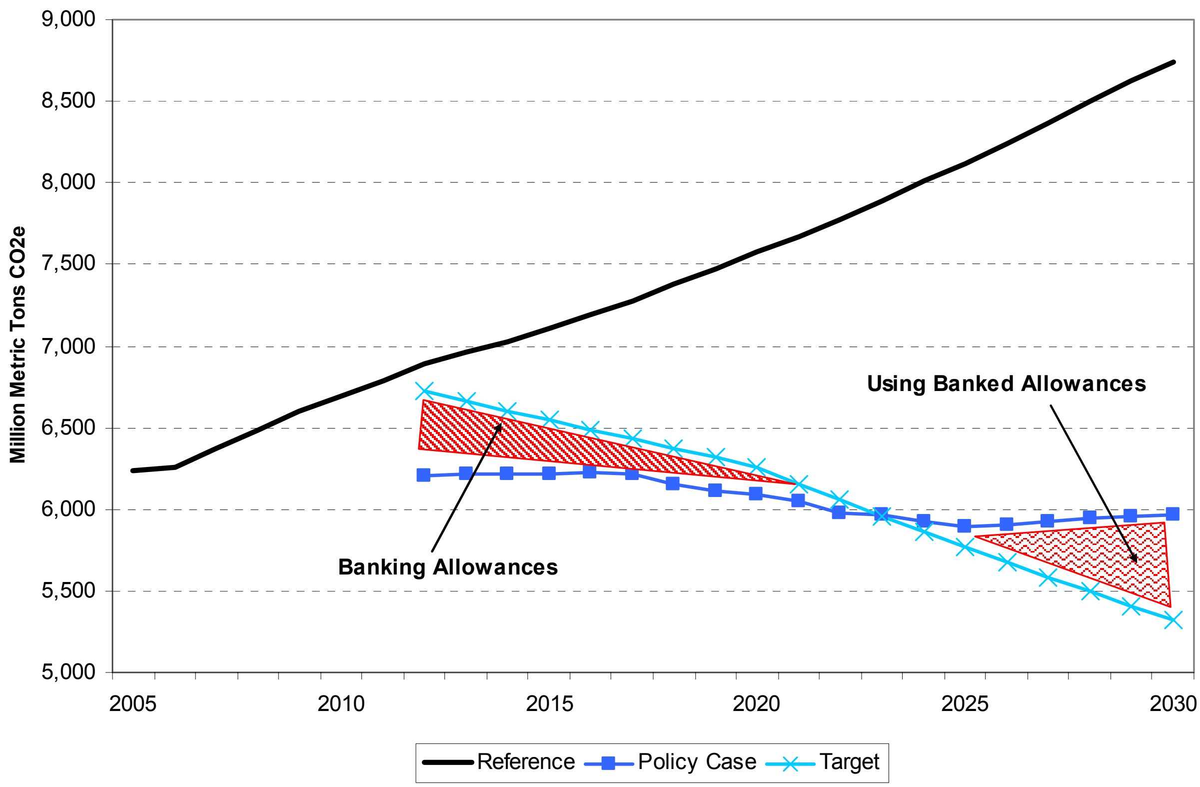
expenditures by 2030 funded from auction revenues. Additional auction revenues that flow to the government are assumed to be used for deficit reduction.

7 Covered sources include sources of energy-related CO_2 emissions, coal mine methane, nitrous oxide emissions from adipic acid and nitric acid production, and industrial gases (HFCs, PFCs, and SF6). Global warming potential (GWP) conversion factors for non-CO_2 greenhouse gases are taken from the Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001).

8 Cumulative emission reductions include certified emission reductions or "offset credits" from non-covered sources. Unless otherwise stated, the term "greenhouse gas emissions" refers to emissions from all covered sources less offset credits. Additional reductions from agricultural sequestration activities are not included in the totals reported here.

above the target as banked allowances are used for compliance. Even with the use of banked allowances, however, emissions in 2030 are 4 percent below current (2006) levels (Figure 1). Allowance prices start at approximately \$4.50 per metric ton CO_2e in 2012 and rise to nearly \$20 per metric ton CO_2e by 2030 (in real 2004\$), but remain below the safety valve price throughout the forecast period.[9] Overall, program targets are met and no additional allowances are purchased through the safety valve mechanism.

Figure 1: Covered Emissions Less Offsets



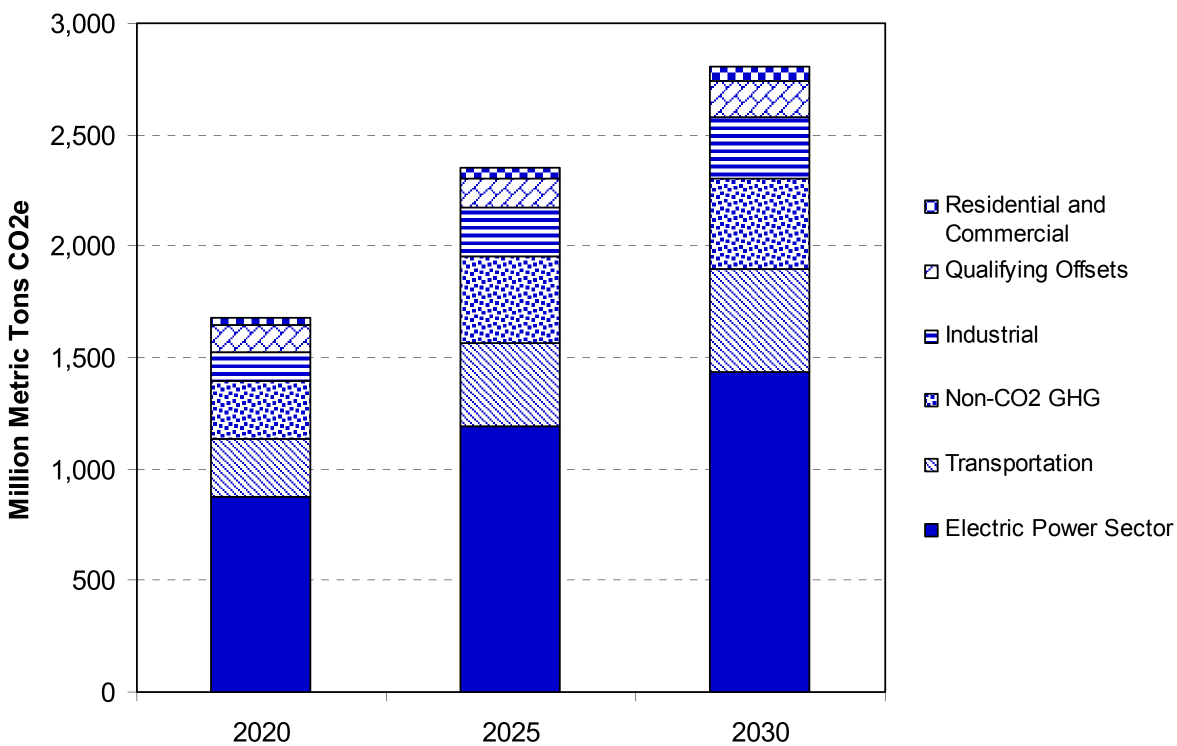
Reductions from energy-related carbon dioxide emissions account for roughly 80 percent of projected reductions in the 2020–2030 timeframe. The largest emissions reductions are forecast in the electric power and transportation sectors as a result of the greenhouse gas trading program and more stringent Corporate Average Fuel Economy (CAFE) requirements (see Figure 2). These two sectors account for 53 percent and 15 percent, respectively, of total cumulative emissions reductions over the forecast period In contrast, primary energy consumption in the residential, commercial, and industrial sectors combined accounts for a much smaller percentage (6–12 percent) of annual emissions reductions over the forecast period, although emissions within the industrial sector are nearly 20 percent below the reference case by 2030. Remaining

[9] As a result of banking, allowance prices rise at the real discount rate—in this case, 8.5 percent—so that the cost of early versus later reductions is equivalent when adjusted for differences in timing.

reductions come from other covered greenhouse gases, the bulk of which involve industrial emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur-hexafluoride (SF_6).

The modeling analysis also accounts for the inclusion of a well-defined offsets program to promote cost-effective emission reductions from non-covered sources. The Commission has recommended that emissions offsets be limited to non-covered sources where there is a strong likelihood that emissions benefits can be reliably verified and monitored over time.[10] In the modeling analysis, offsets account for 6–7 percent of the overall emissions reductions implemented between 2020 and 2030 to meet program targets. The modeling analysis also includes a "set-aside" program in which a small percentage of the total annual allowances are used to provide incentives for agricultural storage activities. Because the allowances for the set-aside program are taken from the total pool of available allowances, emission reductions from agricultural storage activities should be viewed as additional reductions beyond those needed to meet the program targets. The set-aside program results in an additional 240–345 $MMTCO_2e$ of reductions annually.

Figure 2: Emission Reductions by Sector



[10] Eligible offset projects in this analysis include landfill methane projects, animal waste methane projects, municipal wastewater methane projects, and measures to reduce SF_6 emissions from electrical transformers. Credits for CCS projects at power plants are included in electric-sector emission reductions.

Sector-Level Impacts

The Commission's modeling analysis provides further insights on specific impacts at the sector level. Subsequent sections review results for the electric power sector, the transportation sector, and primary fuel markets.

Electric Power Sector: The combination of a CO_2 price signal and supplemental policies—notably a national-level RPS and deployment incentives for CCS [11]—produces significant shifts in the resources and technologies used for electricity generation. Over the next two decades, both generation and new capacity shift away from carbon-intensive sources, particularly conventional pulverized coal plants, to nuclear, renewables, and advanced coal systems with CCS. In addition, the modeling results for 2030 show substantially lower levels of electricity generation and capacity in the policy case compared to the reference case. Improvements in end-use efficiency significantly reduce electricity use, principally in the residential and commercial sectors. Electricity demand in the reference case is projected to grow 45 percent by 2030, while demand in the policy case grows only 35 percent.

Not surprisingly, electricity generation from renewable resources (excluding existing hydropower)—particularly from wind and biomass—increases substantially under the package of policies analyzed. Electricity from these sources accounts for 13 percent of total sales by 2020 (compared to 1 percent in the reference case), and 18 percent by 2030 (compared to 2 percent in the reference case). Lower electricity demand substantially reduces the need for new generating capacity in the policy case—as a result, there are fewer opportunities for new renewable plants to enter the market. In absolute terms, wind capacity reaches 94,000 MW by 2030 in the policy case, compared to 20,000 MW by 2030 in the reference case; similarly biomass capacity in the policy case reaches 66,000 MW by 2030, compared to 5,000 MW in the reference case. (Current installed wind and biomass capacity totals approximately 10,000 and 2,000 MW, respectively.) Combined, over 157,000 megawatts of new renewable capacity are added by 2030 in the policy case.

While nuclear capacity also grows, modeled increases are much less dramatic than in recent NEMS analyses.[12] This is due in large part to the incentives provided for CCS in the policy case analyzed. These incentives drive down the cost of advanced coal systems, making them more economically attractive than nuclear plants. In the reference case, 9,000 MW of nuclear capacity are added by 2030— 3,000 MW through upgrades at existing plants and 6,000 megawatts through new plant construction. In the policy case, by contrast, the total increase in nuclear capacity over the same timeframe is 26,000 MW and nuclear power's share of overall generation remains roughly constant at 20 percent.

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[11] To simulate the bonus allowance program for CCS recommended by the Commission, all advanced coal generation with CCS built by 2030 receives a 1.7 cent per kilowatt-hour production tax credit. This is slightly below the current 1.9 cent per kilowatt-hour tax credit for renewables to reflect the fact that CCS systems would likely capture 90 percent (rather than 100 percent) of carbon emissions. As with the renewable production tax credit, plants receive the credit for the first 10 years of operation.

[12] See, for example, the January 2007 EIA report: *Energy Market and Economic Impacts of Reducing Greenhouse Gas Intensity with a Cap and Trade System* at http://www.eia.doe.gov/oiaf/servicerpt/bllmss/pdf/sroiaf(2007)01.pdf.

Fossil-fired generation, meanwhile, declines from forecast levels under the policy case, but remains roughly equivalent in absolute terms by 2030 compared to current levels. The analysis indicates that while some 47,000 MW of existing coal capacity are retired by 2030, more than 81,000 MW of advanced coal with CCS are added. Overall, coal-fired generation accounts for 44 percent of total electricity generation in 2030—15 percent less than in the reference case. Natural gas capacity increases by just 9,000 MW in comparison to the reference case forecast. Although natural gas-fired combined-cycle capacity increases slightly by 2030 compared to the reference case, older, less efficient oil/gas steam units are retired, holding natural gas capacity relatively steady.

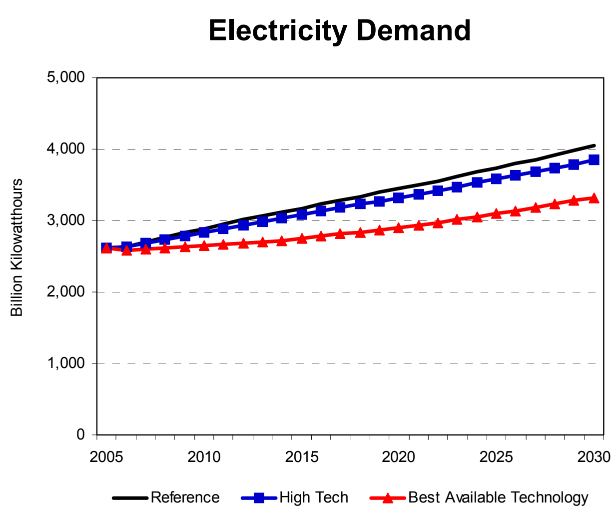
Several factors combine to mitigate any increase in electricity prices that would otherwise result from higher fossil fuel prices. As noted above, the substantial reduction in projected electricity demand reduces the need for new capacity and allows less efficient plants to be retired. Fewer new power plants and incentives for renewables and CCS lead to lower natural gas demand in the electric sector. These factors, combined with end-use efficiency improvements in other sectors, lead to a decline in delivered natural gas prices for the electric sector. Because natural gas-fired generation often sets the price in competitive electricity markets, lower natural gas prices offset much of the impact of higher fossil-fuel prices from the greenhouse gas trading program. As a result, the average price of electricity nationwide in the policy case is slightly below the reference case through 2025.

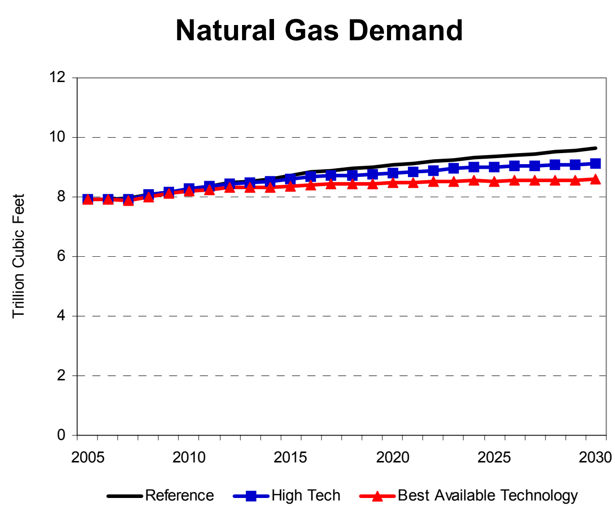
Efficiency and Technology Assumptions

As noted in the main text, EIA's "High Technology" side case from the Annual Energy Outlook 2006 was used as a proxy for the Commission's recommendations when modeling energy efficiency in the residential and commercial sectors. This case assumes earlier availability, lower costs, and/or higher efficiencies for end-use equipment than EIA's reference case, as well as greater improvements in building-shell efficiency. Equipment assumptions were developed by engineering experts, assuming increased research and development in advanced end-use technologies.* In the High Technology case, all new construction is assumed to meet Energy Star specifications after 2010.

The Commission also modeled its policy scenario using EIA's more aggressive "Best Available Technology" case as an alternative proxy for its efficiency and technology R&D recommendations. This case assumes that all equipment purchases and construction practices from 2007 forward reflect the most efficient choice available in the High Technology case, regardless of cost.

When either of these efficiency side cases is modeled along with the Commission's other policy recommendations concerning vehicle fuel economy, carbon capture and storage, and renewable energy, proposed greenhouse-gas reduction targets are achieved without triggering the trading-program safety valve and the model projects a slight *increase* in future economic growth compared to the reference case. A comparison of modeling results under the High Technology and Best Available Technology side cases underscores a further important point: the additional efficiency investment reflected in the Best Available Technology case achieves substantial additional benefits compared to the High Technology case. Importantly, it leads to significant further reductions in projected demand for electricity and natural gas and substantially less need for new electric-generating capacity. As a result, delivered prices for electricity actually decline in the Best Available Technology case compared to a slight increase predicted after 2025 in the High Technology case, and there is a slightly larger gain in projected GDP for 2030 (a 0.3 percent increase instead of a 0.15 percent increase).





* The high technology assumptions are based on EIA, Technology Forecast Updates-Residential and Commercial Building technologies-Advanced Adoption Case (Navigant Consulting, September 2004).

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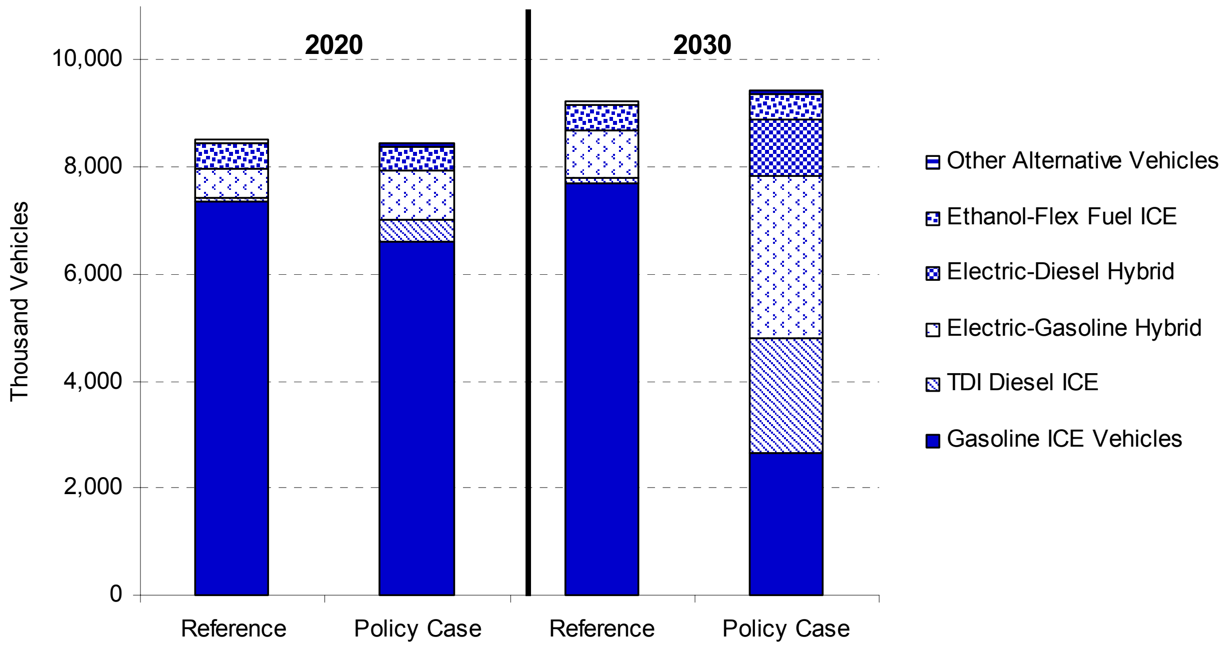
Transportation Sector: More stringent fuel-economy regulations play a more significant role in driving modeling results for the transportation sector than does the CO_2 price signal introduced by the greenhouse gas trading program. In the reference case, the average fuel economy of new cars and light trucks increases just 4 miles per gallon (mpg), from a current combined average of 25 mpg to 29 mpg in 2030 (this improvement occurs in part as a result of recently adopted changes in the CAFE standard for light trucks). As noted previously, the policy case assumes that the average combined car and light-truck fuel economy of new vehicles increases by 16 mpg to a new average of 41 mpg in 2030 (this scenario is modeled as a proxy for the Commission's recommendation for a 4 percent per year presumptive increase in CAFE standards subject to modification by NHTSA if safety, cost, or economic considerations warrant).

Due to a lag in fleet turnover, the average fuel economy of the in-use light duty fleet improves more slowly than the fuel economy of new vehicles. Specifically, in-use fleet fuel economy improves by just 2 mpg in the reference case (from 20 mpg in 2005 to 22 mpg in 2030). By comparison, in-use light duty fleet fuel economy in the policy case increases to 25 mpg by 2020 and 30 mpg by 2030.

The modeling analysis suggests that hybrid-electric, advanced diesel, and flex-fuel vehicles will play an important role in achieving significantly higher fuel-economy standards. In the reference case, sales of gasoline-electric hybrids are projected to reach 6 percent of new vehicle sales by 2020. By comparison, gasoline-electric hybrids and advanced diesels achieve much higher penetration of the new car market in the policy case, together comprising as much as 19 percent of new light-duty vehicles sales by 2020 and 64 percent of new light-duty vehicle sales by 2030. The price of the average new vehicle in 2030 rises $3,500 (or 12 percent) higher in the policy case compared to the reference case.

Figure 4: Light-Duty Vehicle Sales by Fuel Type



F.3 Primary Fuels: Fossil-fuel consumption falls considerably in response to the Commission's recommended policies. Overall fossil-fuel use in the policy case is 92 quads in 2030—20 percent below the reference case forecast, although still slightly above the current (2006) level of consumption. The largest reduction is in coal consumption, which falls from 35 quads in the reference case in 2030 to 24 quads in the policy case. While lower demand for coal in the electric sector accounts for the bulk of this decline, industrial sector demand for coals falls 51 percent compared to the reference case by 2030 and accounts for 17 percent of reduced coal demand. In absolute terms, however, projected coal consumption in the policy case in 2030 is equivalent to current (2006) consumption.

Oil consumption in 2030 is roughly 17 percent lower in the policy case than in the reference case in 2030, largely as a result of improved light-duty-vehicle fuel economy. Gasoline consumption is 21 percent below the reference case in 2030 and accounts for just over half of the total projected reduction in oil demand. The remaining reductions in oil use come primarily from other transportation fuels and the industrial sector, where demand falls 17 percent compared to the reference case in 2030. Imports of both crude oil and refined products decline substantially due to lower U.S. consumption, falling 14 percent and 33 percent respectively compared to the reference case in 2030.

Demand for natural gas declines in all sectors, and by 2030 is 13 percent below the reference case. The largest demand reduction for this fuel occurs in the electric sector, where natural gas demand falls by 35 percent. This decline accounts for roughly two-thirds of the total reduction in natural gas demand. As noted previously, significant improvements in end-use efficiency in the residential and commercial sectors, combined with incentives for renewables and CCS, drive down electricity demand. For 2030, residential sector natural gas demand is 8 percent lower in the policy case than in the reference case; the corresponding demand reduction in the commercial and industrial sectors is 6 percent.