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Secular Trends, Environmental Regulations, and Electricity Markets

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RESOURCES FOR THE FUTURE

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Abstract:

The confluence of several pending environmental rulemakings will require billions of dollars of investment across the industry and changes in the operation of facilities. These changes may lead to retirement of some facilities, and there has been much debate about their potential effects on electricity reliability. Only very exceptional circumstances would trigger supply disruptions; however, the changes may affect electricity prices, the generation mix, and industry revenues. Coincident with these new rules, expectations about natural gas prices and future electricity demand growth are changing in ways that also will have substantial effects on the industry. This paper addresses these two sets of issues using a detailed simulation model of the U.S. electricity market. The findings suggest that recent downward adjustments in natural gas prices and electricty demand projections have a substantially larger impact on electricity prices and generation mix than do the new environmental rules.

Key Words: air pollution, electricity, regulation, equilibrium model

JEL Classification Numbers: Q41, Q52, Q58

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Dallas Burtraw, Karen Palmer, Anthony Paul, and Matt Woerman*

1. Introduction

The U.S. Environmental Protection Agency (EPA) is in the process of promulgating several new environmental regulations focused on air emissions from the electricity sector. EPA recently issued the final version of the Cross State Air Pollution Rule (CSAPR) designed to improve compliance with fine particulate and ozone National Ambient Air Quality Standards (NAAQS) in the eastern half of the country by reducing emissions of nitrogen oxides (NO_x) and sulfur dioxide (SO_2). For the moment, CSAPR is in flux as the DC Circuit of the U.S. Court of Appeals delayed the rule on December 30, 2011, pending judicial review. EPA also has issued the Mercury and Air Toxics Standards (MATS), which cover emissions of hazardous air pollutants. Implementation of these rules is expected to require billions of dollars of investment across the industry and changes in the facility operations that may lead firms to retire some generating units in lieu of improving in their performance. Coal-fired power plants are most directly affected, but other technologies will be affected as the utilization of generation resources adjusts.

A number of studies conducted in the past two years analyze the effects of these new regulations on the electricity sector, including potential effects on electricity supply, system reliability, and consumers. Several of these studies focus primarily on reliability effects and the extent to which regulations may lead to generating unit retirements, in turn placing at risk the ability of particular regions to meet their reserve requirements over some time frame. The reports use a range of methodologies and assumptions about the different regulations and, as a consequence, reach a variety of different conclusions, ranging from large potential losses in existing capacity—with adverse impacts on reserve margins and thus negative effects on system reliability—to no expected reliability impact.

Industry response to these new regulations will depend on a complex set of technological, regulatory, and market factors. Coming into compliance with these regulations will alter

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investments in new generation and system operations and require additional investment in retrofit pollution control at existing facilities. The effects these changes will have on electricity prices will vary by region, both because some of the regulations are not national in scope and because of regional differences in electricity market regulation and current fuel use for electricity supply.

This paper addresses these issues using a detailed simulation model to examine the effects of regulatory requirements and changes in underlying fuel price and demand forecasts. It is important to consider these issues in an equilibrium model because, in general, achieving reliability requirements affects retail prices, which feed back to affect the economics of investment decisions at existing and new facilities. Investments in retrofits that do not appear economic at current prices may become so once market prices respond to the new regulatory environment and the fact that a number of facilities may either retire or install controls, either of which could contribute to an increase in market prices. Specifically, we model CSAPR, which imposes important limits on emissions of SO_2 and NO_x in the eastern half of the country (where most of these emissions occur), and MATS, which places limits on emissions of heavy metals, including mercury, arsenic, chromium, and nickel, and of acid gases, such as hydrogen chloride and hydrogen fluoride from new and existing generators.

Perspectives on the debate about EPA regulations and electricity market responses also depend on what is happening and expected to happen with fuel prices and electricity demand. Over the past three years, expectations about future prices of natural gas and future demand for electricity have evolved substantially, as reflected in adjustments to the energy forecasts produced by the U.S. Energy Information Administration (EIA) in the Annual Energy Outlook. Between 2009 and 2011, forecasts of future natural gas supply expanded multi-fold and the expected level of future natural gas prices fell substantially (EIA 2009; EIA 2011a).[1] Coincidentally, forecasts of demand levels and growth are also lower due to the current economic downturn as well as expanded investments in energy efficiency that cumulate over time. These changing trends have important implications for expectations regarding future electricity prices and the future operation and profitability of different types of generators. In this paper we offer some perspectives on changes in these baseline assumptions separate from the introduction of environmental regulations, and then compare these changes to consider their relative influences on the future of the electricity industry.

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[1] In the Annual Energy Outlook for 2012 (EIA 2012), the price of natural gas is forecast to be even lower through the year 2025 than in the Annual Energy Outlook for 2011.

An evaluation of the economic effects of environmental policy hinges on the counterfactual. Since 2009, the electricity industry has witnessed secular trends that would have happened with or without changes in environmental policy. These secular trends not only have profound impacts for the industry directly, but also for expectations regarding the effects of environmental policy. In this paper we examine these trends and the corresponding change in the industry in the absence of environmental regulation. From this new baseline, we examine the impact of the new environmental regulations and compare this with the relative influence of the secular changes.

The body of this paper is organized as follows. We begin with a short review of recent studies on the impact of several anticipated regulations, including the Clean Air Transport Rule (the proposed version of what ultimately became the CSAPR) and MATS. We then turn to the results of two sets of modeling analyses. The first focuses on how recent secular trends in fuel prices and electricity demand will affect electricity prices as well as the composition of electricity generation from existing coal and natural gas facilities. In the second modeling analysis we look at the impacts of new environmental regulations under CSAPR (assuming its ultimate implementation) and MATS on the same set of factors.

The effects of these two types of changes—secular economic changes and environmental regulations—can be conflated when one observes changes happening in the industry. However, viewed separately, we find that the secular changes in natural gas supply and electricity demand overwhelm the effects associated with these environmental regulations. We conclude that industry, policymakers, and the public will want to carefully separate the effects of these changes when evaluating the economic consequences of pending environmental regulations.

2. Prior Studies of Proposed and Forthcoming EPA Regulations

EPA is in the process of developing or has recently issued several new regulations focused on electricity generators. The two regulations we focus on are finalized and target emissions of SO_2 and NO_x (CSAPR) and mercury and other air toxics (MATS). New regulations are also being developed to regulate emissions of carbon dioxide (CO_2), solid wastes associated with coal combustion, and the intake of cooling water at thermal power plants. Compliance with these regulations will impose costs on the power sector, and several of the regulations related to air emissions will be of particular concern for coal-fired plants. The expectation of high compliance costs and, to some extent, the coincident timing of the deadlines for compliance under several of these regulations have raised concerns among industry participants and observers that the regulations could have adverse effects on the reliability of electricity supply.

Numerous studies over the last two years look at the effects of some or all of these regulations.[2] The studies focus, to varying degrees, on a number of factors, including the amount of investment in retrofit pollution controls at existing generators that will be necessary for compliance, costs of compliance, retirement of existing coal-fired generators, and impacts on reliability. Several of the studies discuss the expected impact of the regulations on electricity prices. All of the studies were published before the final versions of CSAPR and MATS were issued. These studies draw a wide range of conclusions that depend importantly on several features of the studies, including which regulations were analyzed; how regulation requirements and the required compliance schedule were interpreted; what assumptions were made about the technologies available to firms for compliance; whether or not the study used an equilibrium model to determine the effect on prices and revenues for existing plants; and which sets of regulations were included in the analysis (Macedonia et al. 2011; McCarthy and Copeland 2011).

In general, studies that find regulatory compliance costs at the higher end of the spectrum or higher levels of expected capacity retirement tend to make aggressive assumptions about the requirements of the regulations. This happened in part because studies were conducted prior to the release of the proposed regulation and thus analysts made assumptions about what the final regulation would look like, many of which were not borne out in the end. For example, in contrast to the originally proposed Clean Air Transport Rule (CATR), the final version of CSAPR impacts fewer states and modifies the allowance allocation rules. Studies that consider a broader range of regulations also find higher costs. Also, studies that consider a limited range of compliance options for MATS (Shavel and Gibbs 2010; Braine 2011) tend to find higher costs and more coal plant retirements than those that allow for a broader range of options. For example, Braine finds that 5–7 GW of American Electric Power's coal capacity will retire and its service territory will experience electricity price increases of 20–30 percent as a result of CATR and MATS in combination with new regulations on water intake and coal combustion products. In a national study that looks at a comparable set of regulations, NERA (2011) finds that just under 40 GW of coal-fired capacity will retire as a result of the regulations and average electricity prices will increase by 6.5 percent out to 2020. In contrast, EPA (2011b) finds that just under 5 GW of national coal capacity will retire as a result of CSAPR and an additional 9 GW of coal will retire as a result of MATS. Together these two studies suggest a cumulative price impact of less than 5 percent in the early years, and the size of the price impact declines over time.

[2] For a detailed discussion of these prior studies see (Burtraw et al. 2012)

With the exception of an analysis by the North American Electric Reliability Council (N.E.R.C. 2010), most studies use an equilibrium model to look at the effects of EPA regulations on the electricity sector, which means they can capture the effects of regulations on equilibrium electricity prices in the future as well as their effects on investment in new generation technologies. In these models, electricity price responses to regulations mute incentives for retirement as reductions in the supply of capacity available to meet reserve requirements will tend to raise the prices offered for capacity reserves. Higher prices for reserve services would raise the opportunity cost of retirement and change the economics of plant retrofit decisions.

3. Effects of Demand and Fuel Price Trends on Electricity Supply

The mix of fuels and technologies used to supply electricity depends on a number of factors. Key among them are anticipated growth in electricity demand and the price of fuels used to generate electricity. In addition, the price of fuels has important implications for electricity demand as fuel prices affect electricity prices and electricity prices affect demand. Over the past couple of years, the perspective of energy analysis regarding both future demand growth and future fuel prices, in particular for natural gas, have evolved dramatically. To understand this confluence of forces, we decompose the secular trends in market conditions of electricity demand and fuel prices from the changes that are associated with new environmental regulations. This section examines the secular trends.

We use RFF's Haiku electricity market model (Paul et al. 2009) as a laboratory to understand these trends. The Haiku model contains dynamic price-responsive modules for electricity demand and fuel supply that are calibrated to EIA's forecasts in their reference case projections, but which can vary from these forecasts according to information and policies represented in the model.

Electricity demand in Haiku is represented as a separate system of equations for each of three seasons (summer, winter, and spring-fall), with each season represented by four time blocks (superpeak, peak, shoulder, and base). For each time block, demand is modeled for three customer classes (residential, industrial, and commercial) in a partial adjustment framework that captures the dynamics of the long-run demand responses to short-run price changes. The demand system interacts with electricity supply to identify market equilibrium in each time block. In this paper we compare three different demand systems calibrated to EIA quantity and price forecasts for three reference case scenario forecasts issued by EIA in its Annual Energy Outlooks over three years (EIA 2009; EIA 2010; EIA 2011a).

The evolution in EIA's electricity consumption and price forecasts is driven by investments in energy efficiency manifest at the state and national level as well as the downturn in the U.S. economy over this period. The efficiency investments have a lasting effect in that they are expected to result in more energy efficient capital, which will reduce energy use over the long run. The downturn in the U.S. economy has an important effect in the short run, but that effect decays over time as the economy is assumed to return to normal levels of employment and economic activity. The sum of these two effects is that the 2011 forecast has lower levels of consumption in all future years—and this difference generally increases over time—than either the 2009 or 2010 forecasts. For example, the EIA's 2009 forecast projects an additional 65 TWh of electricity consumption in 2012 compared to the 2011 forecast. By 2025, however, the difference between the projections increases to 142 TWh.

Haiku has reduced-form fuel market modules that endogenously determine prices for natural gas, coal, and biomass. Coal and biomass are differentiated by source and quality of the fuel, and the model calculates delivered prices, including transportation costs. The costs of wind and geothermal resources are represented as supply curves that reflect the increasing cost of those resources as more are taken up. Prices for oil, nuclear fuel, and landfill gas are specified exogenously and may change over time. In this analysis, except for natural gas, we take the 2011 forecasts for all fuels as given and calibrate the price-responsive supply curves in Haiku to EIA's reference case fuel supply data.

The EIA forecasts of natural gas prices have evolved considerably in recent years. The EIA's 2009 forecast projected total natural gas consumption in 2020 of 21.53 TCF at an average wellhead price of $6.84/MMBtu, whereas the EIA's 2011 forecast projects total natural gas consumption in 2020 of 25.34 TCF at an average wellhead price of $4.47/MMBtu. Between these two projections, consumption has increased by 18 percent while the price has fallen by 35 percent.

For natural gas, we vary the supply curves by calibrating to alternative EIA forecasts for the years 2011, 2010, and 2009. In each case, calibration is based on EIA's projection of natural gas consumption and national average wellhead prices for the entire U.S. economy for three cases: low economic growth, reference, and high economic growth. Haiku uses these three data points to derive a linear natural gas supply curve for the entire U.S. economy for each year in the forecast horizon. EIA also reports the projected natural gas consumption by all sectors of the economy except electric utilities. Using these data, Haiku calculates the national average wellhead price for natural gas based on endogenous natural gas consumption by the electric utility sector and exogenous consumption by all other sectors. Also from EIA data, a natural gas markup (transportation fee) is calculated for each region of the country, allowing Haiku to express the delivered natural gas price as a function of electric utility demand for natural gas. This exercise results in a fuel supply system that combines a dynamic representation of EIA's

2011 assessment for all other fuels with EIA's assessment for natural gas in the three different forecasts.

For our baseline, we use the Haiku model for 2011 and compare changes relative to that. Other factors that are included in the 2011 baseline are forecasts for capital costs for new investments and the costs of other fuels. In all of the scenarios discussed in this section, the Clean Air Interstate Rule (CAIR) is assumed to remain in effect.[3] CAIR imposes regional constraints on SO_2 and NO_x emissions similar to but somewhat less stringent than those under CSAPR.

Electricity Price and Consumption

We represent the influence of the evolving forecasts by considering seven scenarios illustrated in Table 1. The columns represent electricity demand systems and the rows represent natural gas supply systems, each calibrated to EIA forecasts for each year indicated. The notations in the cells are the titles of the scenarios that will be used in the analysis that follows.

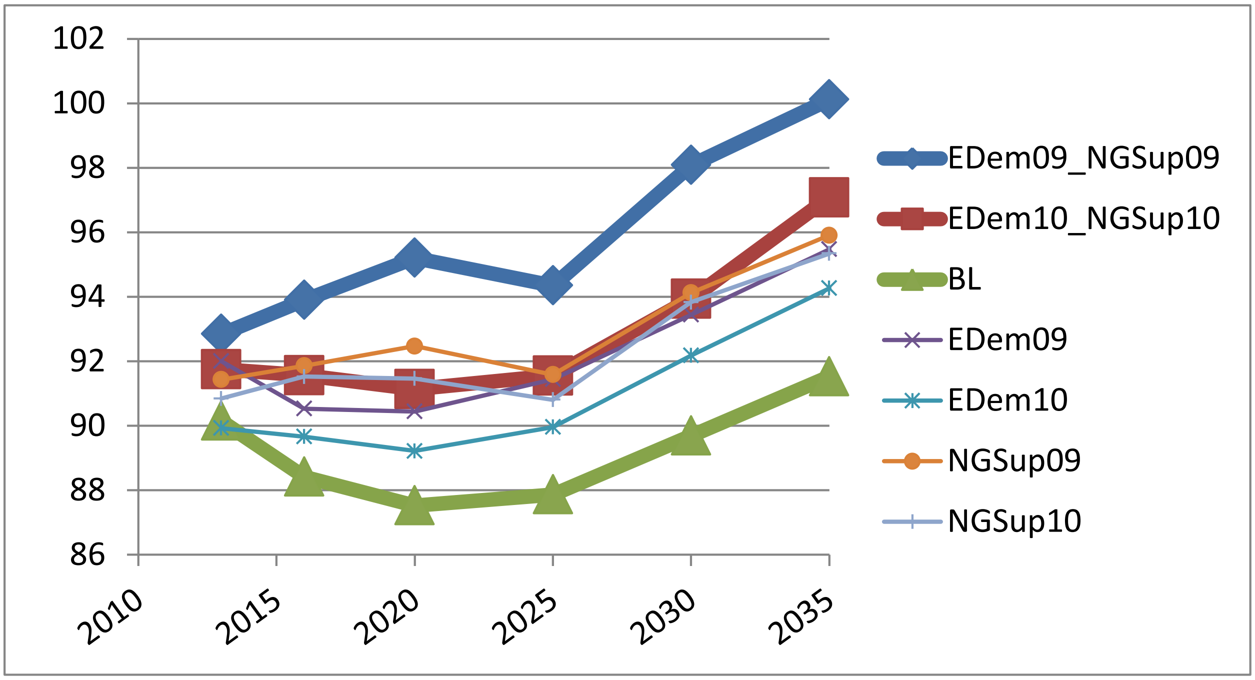
Table 1. EIA Forecast and Scenario Combinations

	2009 Demand	2010 Demand	2011 Demand
2009 Nat. Gas Supply	**EDem09_NGSup09**		**NGSup09**
2010 Nat. Gas Supply		**EDem10_NGSup10**	**NGSup10**
2011 Nat. Gas Supply	**EDem09**	**EDem10**	**BL**

The model results over the forecast horizon for projected national average electricity prices appear in Figure 1. The three bold lines in this figure and those that follow correspond to the diagonal elements of Table 1. Figure 1 illustrates the important effects these forecasts have on expected electricity price. For instance, in 2020 electricity prices fall from $95.2/MWh to $87.5/MWh as we move from forecasts for 2009 to 2011.

[3] CAIR was promulgated in 2005 but subsequently vacated by the DC Circuit Court of Appeals and remanded to the EPA. However, it remains in effect until a replacement is available, which presumably will be CSAPR.

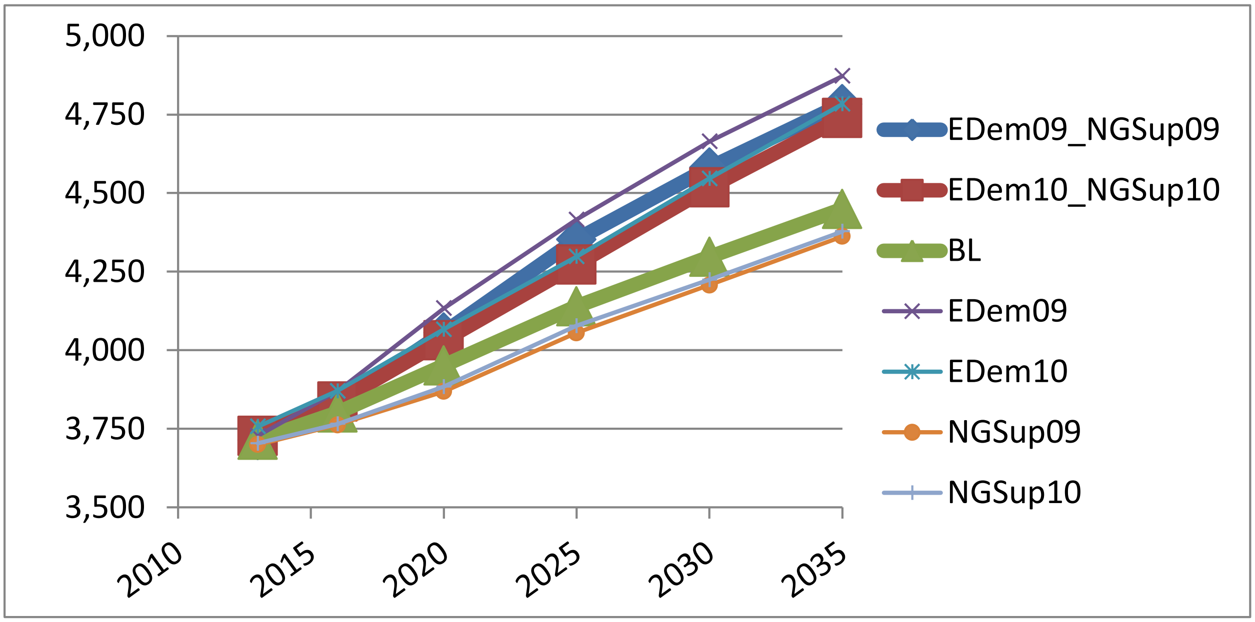
Figure 1. National Average Electricity Price (2009$/MWh)



The complete set of scenarios itemized in Table 1 help explain the changes that occur over these forecasts. Substituting 2010 forecasts for electricity demand (EDem10) or natural gas supply (NGSup10) for those in the 2011 baseline will lead to an increase in electricity prices, as illustrated in Figure 1. Combining both these changes (EDem10_NGSup10) compounds the effect on prices. Similarly, substituting the 2009 forecasts (EDem09 and NGSup09) individually into the 2011 baseline also leads to an increase in the profile of electricity prices, and combining these effects (EDem09_NGSup09) again compounds the impacts.

In a model with parametric, downward sloping demand functions, the decrease in electricity price would yield an increase in electricity consumption, but that does not happen in this equilibrium framework in which different scenarios have different electricity demand curves and electricity price changes are determined simultaneously with the level of electricity demand. In fact, Figure 2 illustrates that the level of electricity consumption falls as we move from forecasts for the year 2009 to 2011. For example, in 2020 the projected quantity of total national consumption falls from 4,056 TWh to 3,952 TWh even as electricity prices also fall.

Figure 2. National Electricity Consumption (TWh)



In Figure 2 one also can compare the effects of changes in the forecast for demand, holding natural gas supply characteristics constant, and vice versa. In the portrayal of total electricity consumption one observes offsetting effects. The greatest profile of consumption occurs in the combination of relatively high electricity demand forecasts for 2009 with relatively low natural gas forecasts for 2011 (EDem09). Conversely, the lowest profile of consumption occurs with electricity demand forecasts from 2011 coupled with natural gas prices from 2009 (NGSup09).

The combination of a lower price and reduced consumption makes for a lower forecast for industry revenues on the whole. For instance, electricity sector revenues for the year 2020 would fall from $386 billion using electricity demand and natural gas prices projections from 2009 (EDem09_NGSup09), to $346 billion in the 2011 baseline scenario (a decrease of 10.4 percent), holding everything else in the model constant. This change in revenues will have a direct and significant effect on the profitability of existing capacity and new investments.

Technology Choice

The overall decrease in projections of electricity consumption since 2009 could be expected to lead to a decrease in generation from all technologies. However, the increase in natural gas supply from 2009 to 2011 might result in greater natural gas generation and a substitution from generation with other fuels, including coal. Figure 3 shows these effects do occur. For instance, in 2020 the model suggests coal generation falls from 2,105 TWh to 1,836

TWh when comparing the 2009 and 2011 electricity demand and natural gas supply forecasts, holding everything else constant. Low natural gas prices have already started to have an effect on the mix of fuels used to supply electricity, and in November and December of 2011, coal's share of net electricity generation fell to under 40 percent for the first time in over 30 years (EIA 2012).

The decrease in coal generation is made up in part by an increase in natural gas generation. Figure 4 illustrates this change. In 2020, for example, natural gas generation increases from 572 TWh to 836 TWh.

One consequence of the change in the quantity of electricity consumption and the choice of technologies and fuels is a change in the environmental performance of the industry. In fact, we find relatively little change in emissions of SO_2 and NO_x because these emissions are regulated by CAIR-level emissions caps in all the scenarios we have described thus far. However, there is a notable difference in emissions of CO_2. For example, the projected emissions for the year 2020 based on information in EIA's 2009 forecasts are 2.6 billion short tons. Using information in EIA's 2011 forecasts, we find emissions fall by 9 percent to 2.3 billion short tons.

Figure 3. Coal Generation (TWh)

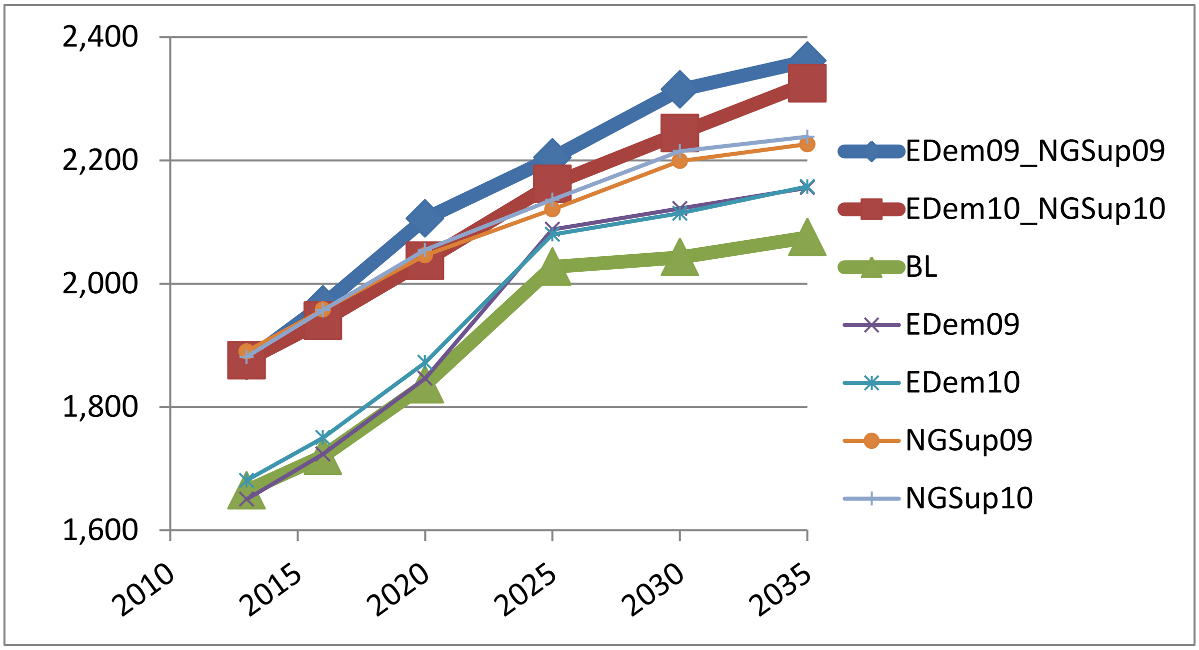
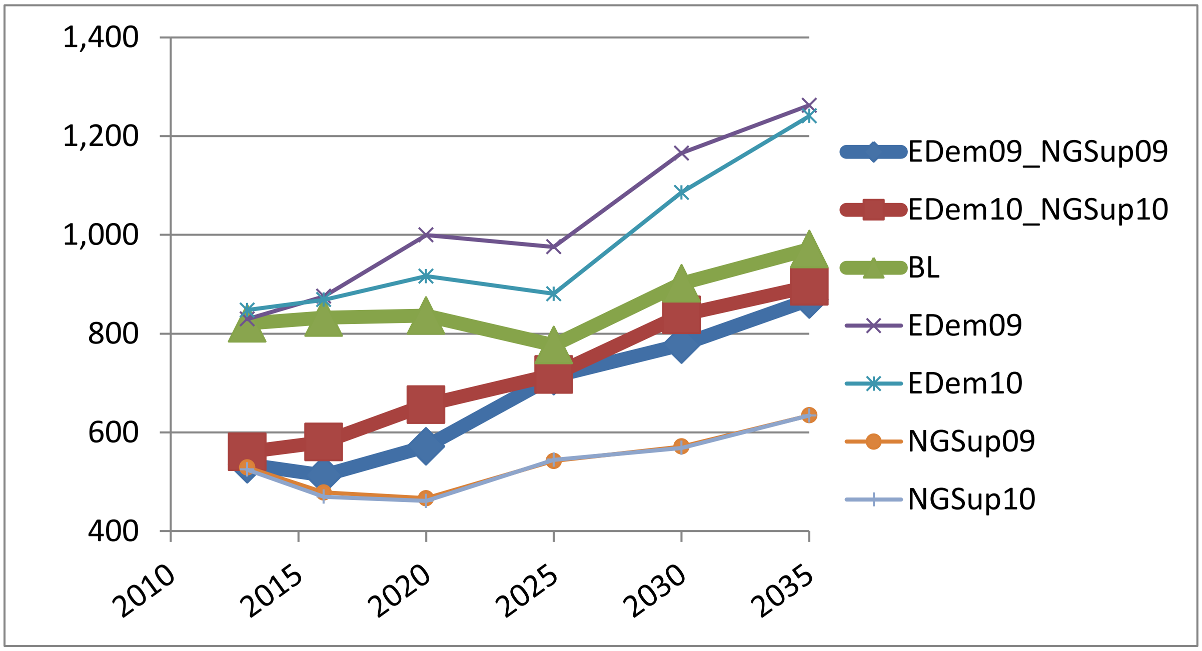


Figure 4. Natural Gas Generation (TWh)



Summary of Effects Stemming from Trends in Demand and Fuel Prices

The changes in electricity demand and natural gas supply that have emerged in the last two years lead to an important decrease in the forecast for generation from coal and an increase in reliance on natural gas for electricity generation. These trends also result in lower electricity prices and lower aggregate consumption, which combine to have a significant effect on the revenues that will be earned by the electricity industry. They have a particularly large effect on the profitability of coal-fired generators, which see a decrease in aggregate demand and disadvantageous change in relative prices compared with natural gas.

The changes in electricity demand and natural gas supply have an inconsequential effect on emissions of SO_2 and NO_x because these emissions are regulated under emissions caps. However, the changes will have a direct effect on CO_2 emissions, which decline by 9 percent. These substantial changes in the operation and characteristics of the electricity industry all occur in the absence of changes in environmental regulations, which we consider next.

4. Modeling Analysis of CSAPR and MATS

Two of the most important environmental regulations to affect the electricity industry are CSAPR and MATS. CSAPR will reduce emissions of SO_2 and NO_x in 27 eastern states by setting caps on emissions of these pollutants. For NO_x, CSAPR includes separate caps for ozone season and annual emissions, and for SO_2, it assigns caps for two different groups of states. It allocates emissions allowances to covered entities and allows unlimited intrastate and limited interstate trading of pollution credits between power plants. The regulation is expected to have substantial environmental benefits (EPA 2011a). How one evaluates the benefits and costs of the regulation and the impacts on the industry depends entirely on what it is compared against. In evaluating the impact of CSAPR, we assume the regulation survives its legal challenge and takes effect beginning in 2012, with additional reductions in SO_2 emissions required by 2014.[4]

The more proscriptive and geographically comprehensive of the two new regulations, MATS requires reductions of emissions of heavy metals and acid gasses from coal-fired generators across the country beginning in 2014. This regulation does not allow trading to achieve the emissions reduction requirements. In this modeling analysis, MATS is evaluated both as a stand-alone addition to baseline CAIR regulations of SO_2 and NO_x and in combination with the CSAPR rule.

Electricity Price and Consumption

Figure 5 illustrates the effect on electricity prices of the implementation of CSAPR (and the termination of CAIR) and the implementation of MATS measured against the 2011 baseline. The 2011 baseline assumes CAIR remains in effect, as does the 2009 baseline (EDem09_NGSup09), which includes the 2009 assumptions for electricity demand and natural gas supply functions.

The effect of CSAPR on electricity prices is very slight, and sometimes negative. The MATS rule consistently raises prices, but the increases are still slight.[5] The effect of both CSAPR and MATS combined is illustrated by the label "CSAPR_MATS." Compared to the effects of secular changes in electricity demand and natural gas supply projections and electricity prices, the effects of CSAPR and MATS considered separately or in tandem are small.

Figure 6 reveals a comparable result for the level of total electricity consumption. The very small differences in electricity prices between the three regulatory scenarios and the baseline result in virtually no differences in total electricity consumption. In contrast, the 2009

[4] In fact, CSAPR may be delayed until 2014 when additional emssions reductions would be required anyway under the regulation. Modeling of the early adoption in our model has no effect on our results in 2014 and beyond because investment decisions are driven by consideration of the more stringent emissions targets.

[5] In this analysis Direct Sorbent Injection (DSI) is among the lower cost technology options for reducing emissions of toxics. Some analysts, such as NERA (2011) and Macedonia et al. (2011), have suggested that very large coal-fired generators will not find this approach to control to be cost-effective. Eliminating this option would raise costs of compliance with MATS but we find that the overall impact on electricity price is less than 1 percent and there is roughly 2 percent less coal-fired generation as well.

projections of electricity demand and natural gas supply would have yielded 3 percent more electricity consumption in 2020 than would the 2011 baseline.

Figure 5. Electricity Price Changes under CSAPR (2009$/MWh)

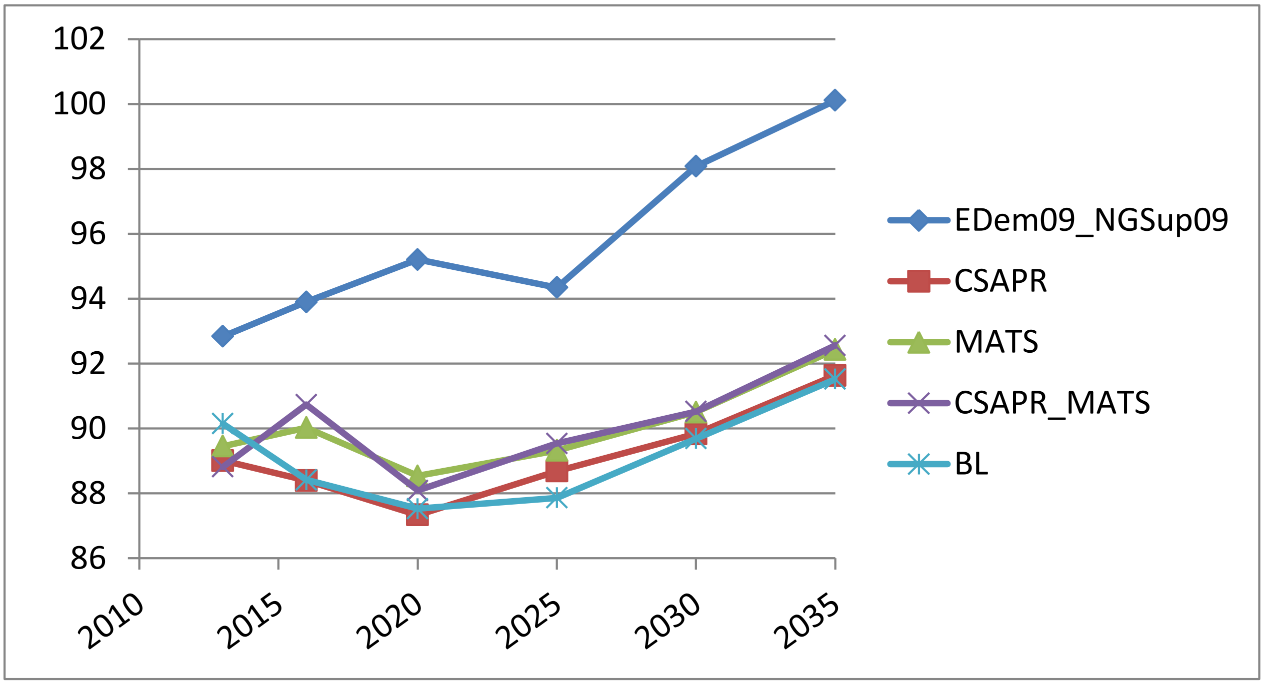
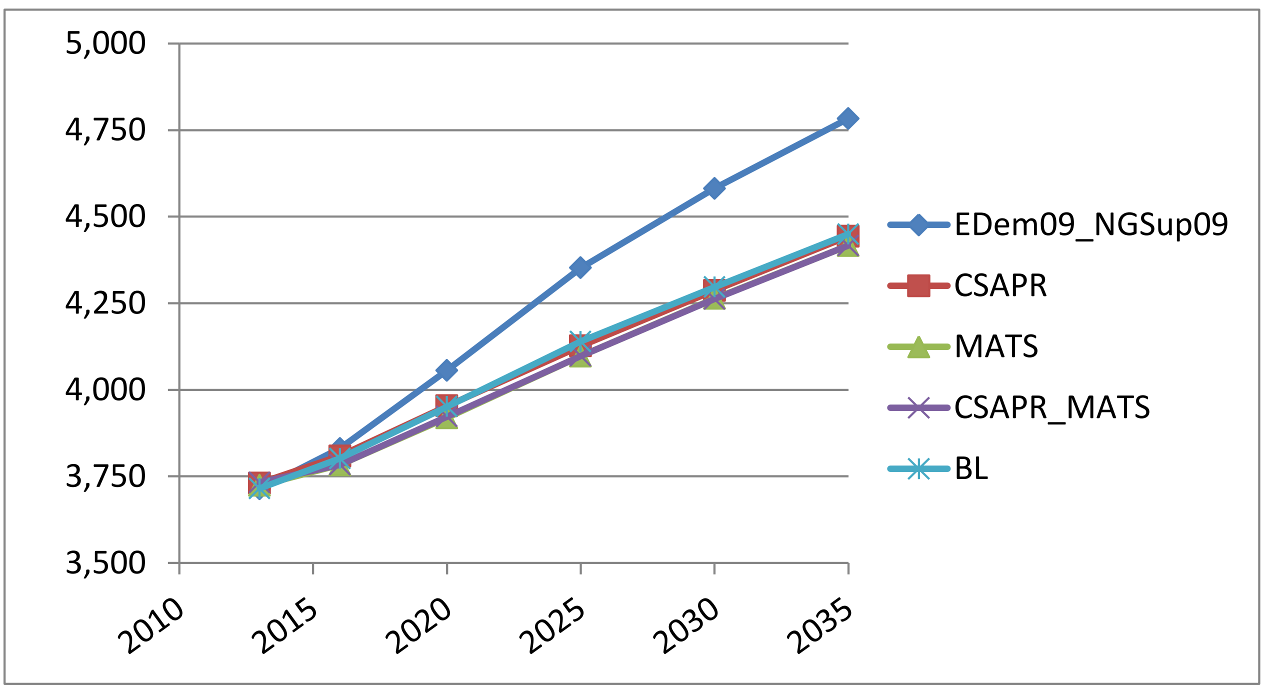


Figure 6. National Electricity Consumption (TWh)



Technology Choice

The changes in technologies used for electricity generation due to CSAPR and MATS are also small. According to Figure 7, MATS by itself results in a small reduction in coal generation in most years. CSAPR by itself has a similar effect in reducing coal generation compared to the baseline, particularly after 2020. These effects appear to be approximately additive in the combined CSAPR and MATS scenario. Throughout the simulation period, the changes in coal generation remain small compared to those that result from the 2009 assumptions for electricity demand and natural gas supply.

Figure 7. Coal Generation (TWh)

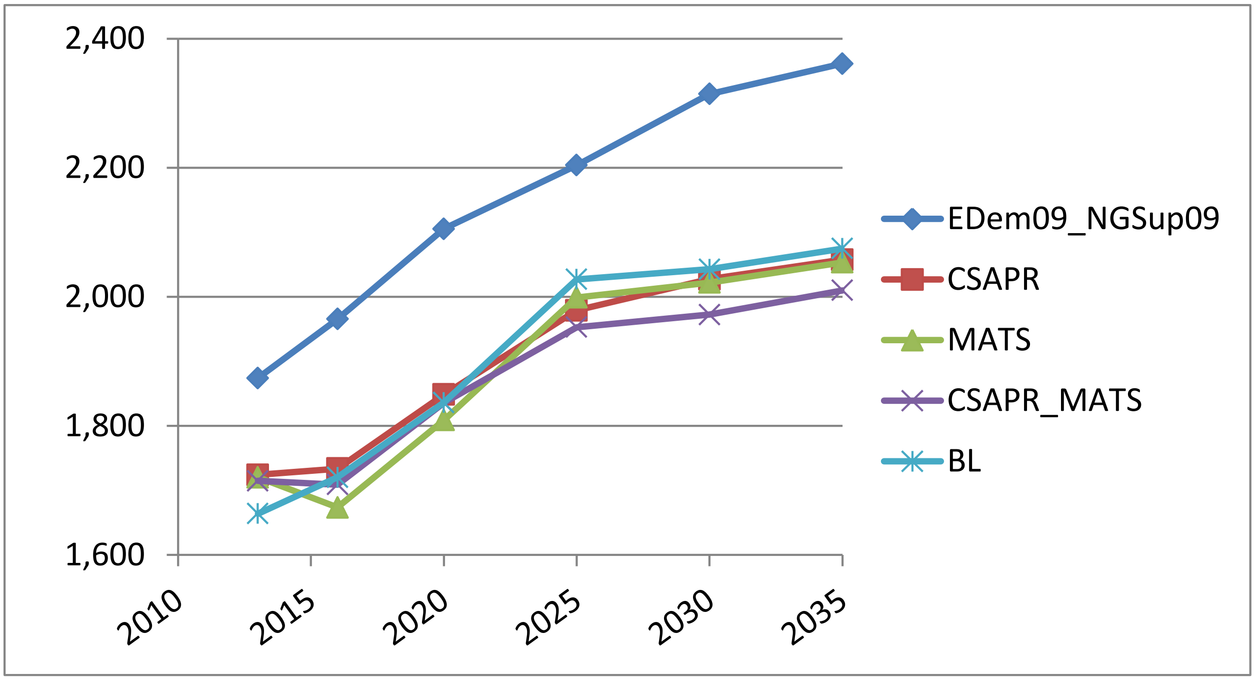
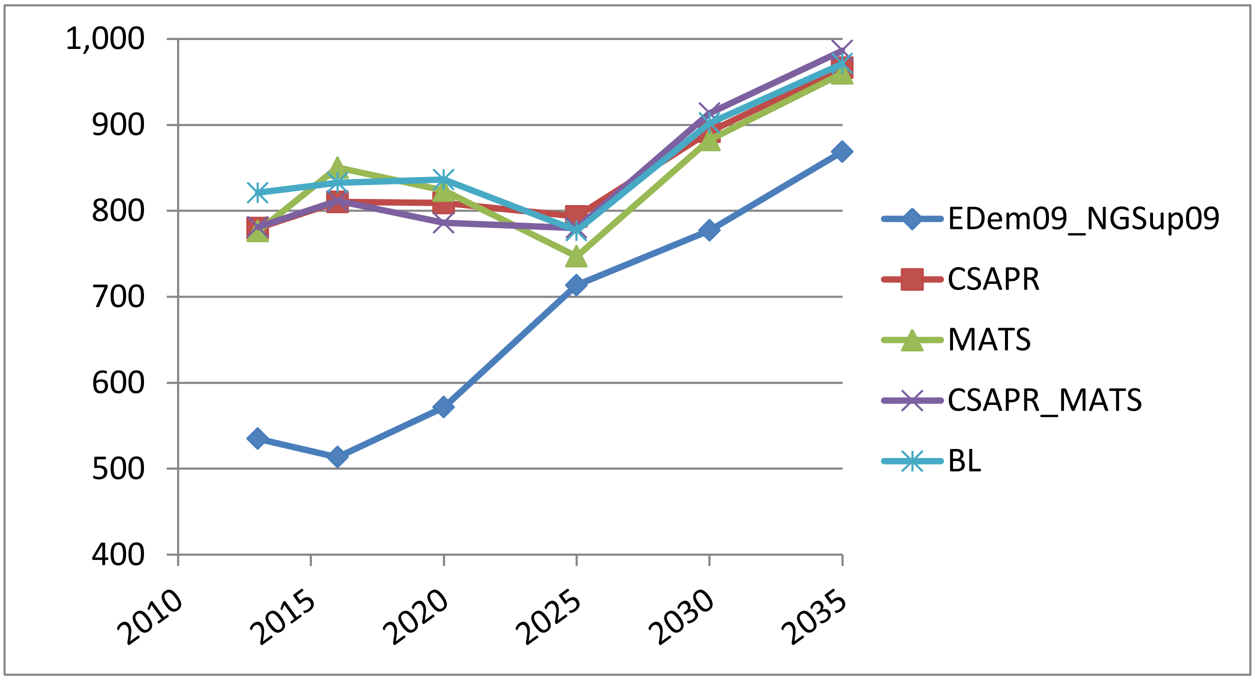


Figure 8 illustrates that either policy has only a small, and typically negative, effect on natural gas generation. Both policies in combination also have a small effect on natural generation, although it is negative in the early years and positive in the later years of the simulation. Again the change is small compared to differences between the baseline using EIA's 2011 information and forecasts based on information from EIA's 2009 forecasts.

Figure 8. Natural Gas Generation (TWh)



The largest effect of CSAPR relative to changes in the baseline forecasts occurs with respect to emissions of SO_2, which indeed are a target of the regulation. Neither of the regulations has an effect on emissions of NO_x, primarily because the BL and EDem09_NGSup09 scenarios include CAIR regulations, which impose limits on NO_x emissions that are comparable to those under CSAPR. Figure 9 illustrates national annual emissions of SO_2 under all the scenarios. National emissions of SO_2 are unchanged between the two baselines because both scenarios assume that CAIR and Title IV are in effect. The introduction of CSAPR initially results in an increase in SO_2 emissions due to different patterns of allowance banking, but, beginning in 2016, national emissions fall below baseline levels by between 6 and 20 percent depending on the year. MATS by itself leads to a higher spike in emissions of SO_2 in early years but has comparable effects to CSAPR in later simulation years.

Figure 9. National Annual Emissions of SO_2 (1000 tons)

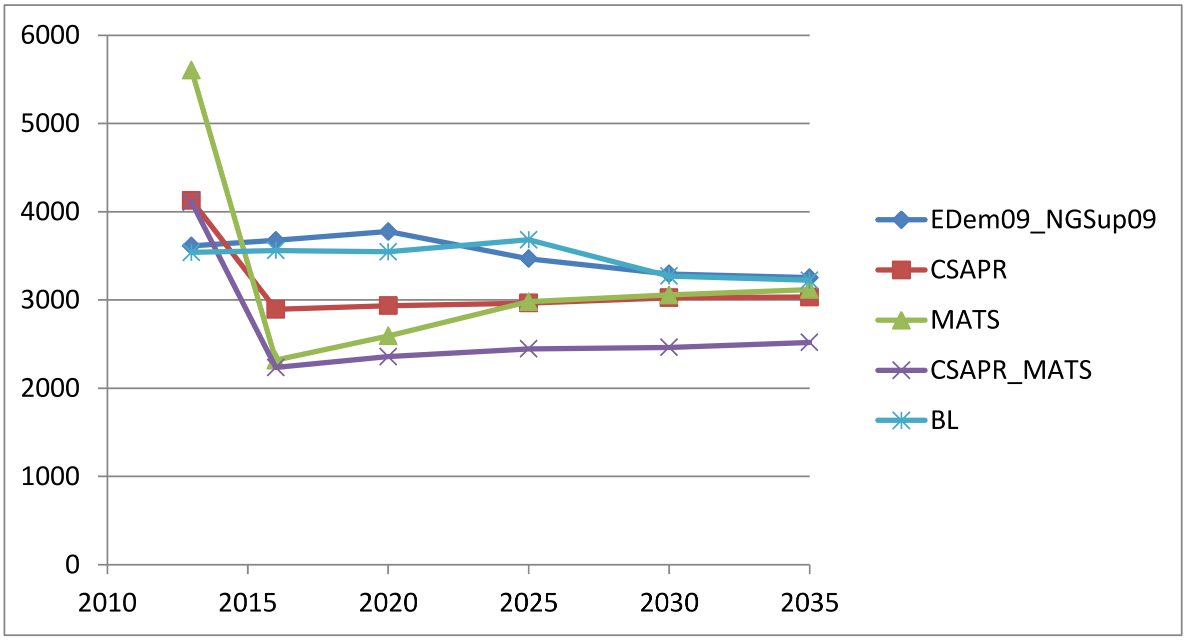


Figure 10 shows that mercury emissions projections are affected by the change in secular trends, but not by the imposition of the CSAPR regulations. MATS leads to substantial reductions in mercury emissions equal to roughly 80 percent of baseline levels.

To understand the effect of these policies on emissions of greenhouse gases we focus on cumulative emissions of CO_2 from the electricity sector beginning in 2013 as shown in Figure 11. CSAPR, MATS, and the two policies in tandem have no effect on CO_2 emissions. The figure illustrates that cumulative emissions at the national level fall by 9 percent when moving from the baseline for 2009 to the baseline for 2011. However, neither CSAPR nor MATS nor the combination of the two has a detectable effect on cumulative emission of CO_2 from the electricity sector.

Figure 10. National Annual Emissions of Mercury from Fossil Units (lbs)

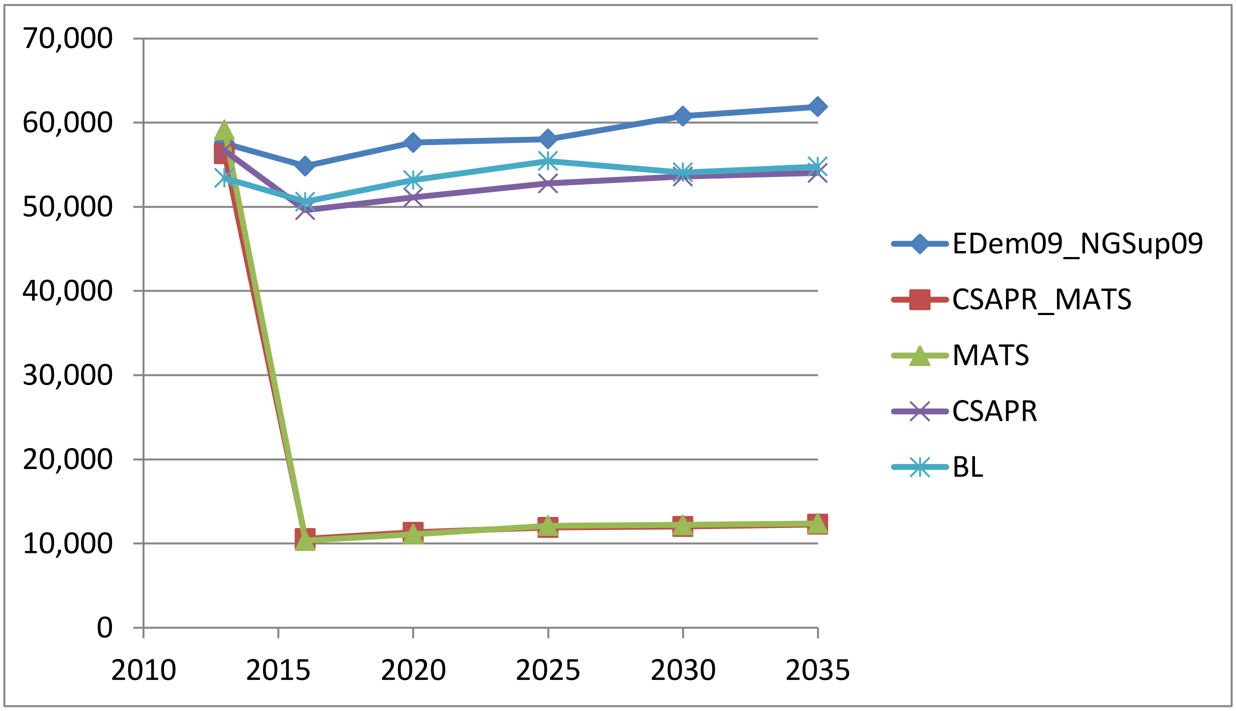
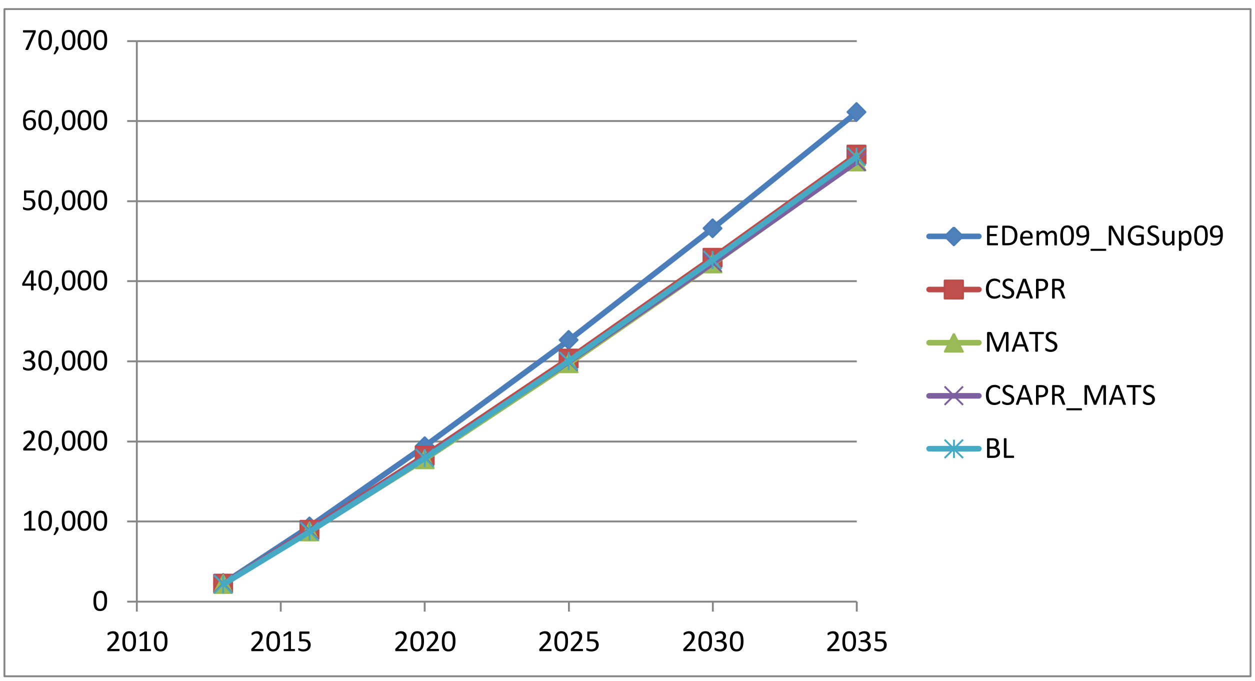


Figure 11. National Cumulative Emissions of CO_2 (million tons)



Summary of Effects of CSAPR and MATS

The implementation of both CSAPR and MATS is likely to produce small changes in the profile of electricity generation and capacity, especially when compared to the relatively much larger impact of secular trends in the electricity industry. The projected changes that are expected under the two regulations, individually and combined, are summarized in Table 2. The columns report the 2011 baseline, a similar baseline that incorporates projections of electricity demand and natural gas supply from 2009, and the implementation of CSAPR beginning in 2012, MATS beginning in 2016, and the two regulations combined. To illustrate the relative influence of these changes in the industry, we measure all percentage changes relative to column 1.

Table 2. Effects of CSAPR and MATS

Year 2020 Values in 2009 dollars	**(1) 2011 Baseline**	**(2) 2009 Baseline**	**(3) 2011 CSAPR**	**(4) 2011 MATS**	**(5) 2011 CSAPR-MATS**
Elec. Price ($/MWh)	87.5	95.2	87.3	88.5	88.1
Percentage change from (1)		*8.8%*	*-0.2%*	*1.2%*	*0.6%*
Total Generation (BkWh)	4106	4231	4108	4074	4080
Percentage change from (1)		*3.0%*	*0.0%*	*-0.8%*	*-0.6%*
Generation by fuel (BkWh)					
Coal	1836	2105	1848	1809	1836
Percentage change from (1)		*14.7%*	*0.7%*	*-1.5%*	*0.0%*
Gas	836	572	809	823	786
Percentage change from (1)		*-31.7%*	*-3.3%*	*-1.5%*	*-6.0%*
Existing Capacity by fuel (GW)					
Coal	321.5	326.3	318.9	317.2	316.6
Percentage change from (1)		*1.5%*	*-0.8%*	*-1.3%*	*-1.5%*
Gas	342.0	341.7	351.8	347.6	353.6
Percentage change from (1)		*-0.1%*	*2.9%*	*1.6%*	*3.4%*
Annual Emissions					
National Hg (K lbs)	92.8	97.3	90.7	50.7	51.0
Percentage change from (1)		*4.80%*	*-2.2%*	*-45.3%*	*-45.1%*
CSAPR SO_2 (M tons)	2.95	3.12	2.22	2.22	1.96
Percentage change from (1)		*5.7%*	*-24.8%*	*-24.8%*	*-33.7%*
National CO_2 (B tons)	2.33	2.57	2.35	2.30	2.33
Percentage change from (1)		*10.3%*	*1.1%*	*-1.2%*	*0.1%*

One of the concerns related to electricity system reliability is the fear that CSAPR and MATS would lead to greater retirement of existing generation capacity. In fact, we find that the

2011 baseline yields retirement of 12.6 GW of existing coal capacity by 2020. CSAPR alone, MATS alone, or CSAPR and MATS in combination leads to additional retirement of only 2.6 to 4.9 GW of existing coal capacity by 2020. This is similar to the projected level of coal retirement due to changes in the conditions facing the industry expected as a result of changes in the baseline between 2009 and 2011. However, these policies also lead to less retirement of existing natural gas capacity. On net, we find these policies lead to an increase in the amount of surviving coal and gas capacity of up to roughly 7 GW in 2020 compared to what would happen under the 2011 or 2009 baselines.

Measured against changes reflected in the 2011 baseline forecast, the largest effects of CSAPR and MATS are the regulations' intended reductions in emissions of SO_2 and mercury. CSAPR has a very small effect on retail electricity price. In 2020 the price is projected to fall by $0.2/MWh, and in 2025 it is projected to increase by $0.8/MWh. These price trajectories are due to the complicated dynamics of capacity investments and the way that their costs are manifest in electricity prices.

Conclusions

The mix of fuels and technologies used to produce electricity depends importantly on their relative costs. Regulations like CSAPR that put a price on emissions of pollutants like SO_2 and NO_x, which are largely associated with burning coal, will make other forms of generation, including generation with natural gas, relatively more attractive compared with coal. In addition, MATS, which imposes emissions reduction requirements for mercury and other air toxics on coal-fired generators, will affect the relative costs of using coal versus natural gas to generate electricity. Recent technological innovations that have enabled extraction of natural gas from shale formations also have changed the economics of electricity generation in a way that favors natural gas and disadvantages coal. Lower prices of natural gas also tend to reduce electricity prices, thereby lowering the profitability of electricity supply, including electricity generated with coal. Evidence of this effect already has had an impact on how electricity is produced; EIA noted a 16 percent increase in daily consumption of natural gas by electricity generators in the summer between 2008 and 2010 (EIA 2011b). Coincident with gas price declines, electricity demand projections also have been falling as a dual consequence of the recession and expected increases in end-use energy efficiency investments. These trends have implications for present and future electricity generator revenues and profits.

How do the effects of environmental regulation stack up in comparison to these secular trends in fuel prices and demand? This analysis shows that the change between 2009 and 2011 in projections of natural gas supply and electricity demand has a much bigger effect on electricity prices, total generation, and generation by fuel than does the introduction of CSAPR or MATS. Indeed for electricity prices, these secular changes drive effects that are generally more than 5 times greater than the effects of CSAPR or MATS. That multiple is even bigger when comparing the effects on electricity consumption and generation from coal.

The one area where the regulations matter more than secular trends is emissions. Introducing CSAPR leads to a substantially larger effect on SO_2 emissions than do the changes in demand and natural gas prices, which only have a very small effect on these emissions. Perhaps more reassuring is that the CSAPR regulation does affect emissions from regulated sources in important ways and apparently with little disruption to the sector, especially in comparison to the normal disruptions associated with a changing world. Similarly, introducing MATS leads to a substantial reduction in mercury emissions from electricity producers. These regulations do not reduce electricity sector emissions of CO_2, but other pending EPA regulations could have an important effect in that regard.[6]

[6] See Burtraw et al. (2012) for an analysis of how EPA's regulation could impact electricity prices.

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