ISSUE BRIEF

The Variability of Potential Revenue from a Tax on Carbon

Considering a Carbon Tax: A Publication Series from RFF's Center for Climate and Electricity Policy

Karen Palmer, Anthony Paul, and Matt Woerman

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Karen Palmer, Anthony Paul, and Matt Woerman[1]

Introduction

Washington is preparing for the upcoming presidential and congressional elections of 2012, and many policy watchers are busy trying to predict what the major items will be on the post-2012 policy agenda in Washington. The outcome of the election will shape this agenda to a large extent, but several of the issues that the government will need to tackle are already self-evident. Among these are the large and growing federal budget deficits, which are historic in size and growing rapidly. Reducing these deficits will require a bundle of spending cuts and new revenue sources, and some see the need to tackle this challenge as an opportunity for major tax reform in the United States. It may also present an opportunity for dealing with one of the most pressing environmental issues of our time, which is reducing the emissions of carbon dioxide (CO_2) that contribute to global climate change. Indeed, imposing a tax on CO_2 emissions could provide a means to discourage emissions of CO_2 and a source of revenue that could be used to address looming deficits and potentially play a role in tax reform focused on cutting taxes on individual and corporate incomes.

The role that a carbon tax could play in these efforts will depend on how much revenue such a tax is likely to produce. Some have estimated that a carbon tax of $10 per ton of CO_2 could generate annual tax revenues of $60 billion (Aldy et al. 2008), and experts suggest that a carbon tax of about $25 would raise roughly $125 billion per year.[2] The amount of carbon tax revenue will

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[1] The authors are Senior Fellow, Center Fellow in the Center for Climate and Electricity Policy and Senior Research Assistant, respectively at Resources for the Future. The authors wish to thank Dallas Burtraw for inspiration and helpful comments, Adam Stern for research assistance and the Smith Richardson Foundation for financial support.

[2] "Considering a U.S. Carbon Tax: Frequently Asked Questions," webpage forthcoming in May 2012. Resources for the Future, www.rff.org.

depend on the level of the tax and how it is designed, including which sectors are covered and whether some of the tax revenues will be designated for special purposes, such as mitigating energy price increases for low-income households or limiting the impact on emissions leakage due to a domestic tax on energy-intensive and trade-exposed industries. Such provisions were included in the Waxman–Markey cap-and-trade bill (HR 2454), and large constituencies would advocate for such provisions in a carbon tax bill as well.

Carbon tax revenues will also depend on conditions in energy markets. Past analysis of economy-wide cap-and-trade programs (U.S. Energy Information Administration [EIA] 2009a) suggests that, for a Waxman–Markey type of policy, with CO_2 prices rising from $18 per ton in 2012 to $65 per ton in 2030, roughly 70 percent of the emissions reductions will come from the electricity sector, even though this sector currently accounts for only about 40 percent of domestic CO_2 emissions. This disproportionate reduction in emissions from electricity compared to other sectors is a result of its heavy use of coal as a fuel and the accompanying large potential for fuel switching. This, in turn, means that electricity ultimately will be responsible for less than 40 percent of the revenues from a carbon tax. The amount of carbon tax revenue from electricity will depend on the role of coal in electricity generation going forward, which in turn will depend on the price of natural gas. It will also depend on the future growth of electricity demand.

In this issue brief, we look at the sensitivity of carbon tax revenues from the electricity sector to carbon tax rates and secular trends in the forecasted levels of natural gas prices and electricity demand (Burtraw et al. 2012). We show that (a) carbon tax revenues from the electricity sector and for the economy will vary substantially with tax rates, (b) realizations of natural gas prices and electricity demand will have an important effect on potential revenues, and (c) the effect of these factors gets bigger the higher the carbon tax rate. Under a carbon tax of $25 per ton in 2020, revenues from the electricity sector can vary by roughly 18 percent and total carbon tax revenues can vary by up to 7 percent. After a point, increases in the tax rate lead to falling tax revenues as the tax base starts to erode with diminishing reliance on fossil fuels and greater use of renewables and nuclear. Lastly, we show that the effects of recent secular trends (that is, trends not driven by policy decisions) toward lower natural gas prices and reduced electricity demand growth almost perfectly offset a carbon tax of $10 per ton in 2020 on the national average retail electricity price.

Model and Scenarios

This analysis uses RFF's Haiku electricity market model (Paul et al. 2009) to look at the effects of different carbon tax trajectories on electricity markets under different assumptions about natural gas prices and growth in electricity demand. 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 can vary from these forecasts according to information and policies represented in the model. Although this analysis is primarily focused on the effects of different policy scenarios on carbon tax revenues from the electricity sector, it also explores other aspects of electricity markets, including electricity prices, electricity generation levels, and the mix of fuels and technologies used to generate electricity in the future. This analysis identifies these effects by comparing the results of simulations with a carbon tax to the relevant baseline scenario without a carbon tax. The assumptions underlying the baseline and policy scenarios are described next.

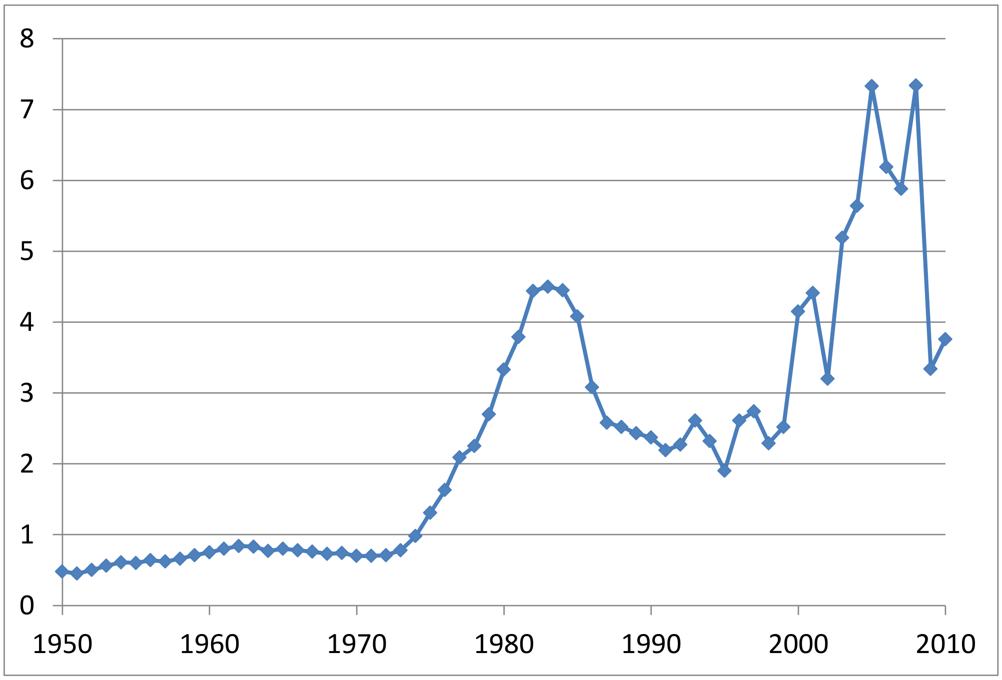
BASELINE SCENARIOS

This analysis includes two baseline (BL) scenarios: one based on natural gas price and electricity demand growth trajectories that are consistent with EIA's Annual Energy Outlook (AEO) from 2011 (EIA 2011a; labeled AEO11 BL in the figures) and another based on EIA forecasts of gas prices and demand in the AEO from 2009 (EIA 2009b; labeled AEO09 BL in the figures). Over this time horizon, the perspective of energy analysis regarding both future electricity demand growth and fuel prices, has evolved dramatically, particularly for natural gas.

The evolution in EIA's electricity consumption and price forecasts is driven by assumptions about investments in energy efficiency, which are driven in part by state and national standards, as well as the slow recovery from the economic downturn of 2008. The efficiency investments have a lasting effect in that they are expected to result in more energy-efficient capital, reducing 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 electricity consumption in all future years than the 2009 forecast, and this difference generally increases over time. For example, EIA's 2009 forecast projects an additional 65 terawatt-hours (TWh) of electricity consumption in 2012 compared to the 2011 forecast. By 2025, however, the difference between the projections increases to 142 TWh. These differences in the two AEO projections are reflected in the two different Haiku baseline scenarios through the different growth rates applied to electricity demand functions.

EIA forecasts of natural gas prices have also evolved considerably in recent years. EIA's AEO 2009 forecast projected total natural gas consumption in 2020 of 21.53 trillion cubic feet at an average wellhead price of $6.84 per million British thermal units, whereas the 2011 forecast projects total natural gas consumption in 2020 of 25.34 trillion cubic feet at an average wellhead price of $4.47 per million British thermal units. Between these two projections, consumption has increased by 18 percent while the price has fallen by 35 percent. In the Haiku model, the supply curve for natural gas is varied by calibrating to alternative EIA forecasts for 2011 and 2009.[3] These recent changes to EIA's projections of natural gas prices reflect the volatile nature of natural gas prices in recent history. Figure 1 shows natural gas prices dating back to 1950 (EIA 2011b). Following a long period of stability, natural gas prices began to rise in the early 1970s and then fall throughout the 1980s, although in a relatively smooth manner. After the deregulation of natural gas prices throughout the early 1990s, however, prices became much more volatile with greater annual changes and sharp increases followed by sharp decreases or vice-versa. This change is best exemplified by the period 2002 to 2009, when the price quickly rose from $3.2 per thousand cubic feet (Mcf) in 2002 to $7.3/Mcf in 2005, and then sharply dropped from $7.3/Mcf in 2008 to $3.3/Mcf the next year.

Figure 1. Annual Average Natural Gas Wellhead Prices (2005$/Mcf)



In all other respects, the underlying assumptions in the two baseline scenarios are identical. These assumptions include estimates of future capital costs for new investments and the costs of other fuels. In all of the scenarios included in this analysis, the Clean Air Interstate Rule (CAIR) is assumed to remain in effect.[4] CAIR imposes regional constraints on sulfur dioxide and nitrogen

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[3] For more information about this calibration and the calibration of electricity demand growth rates in Haiku, see Burtraw et al. (2012).

[4] CAIR was promulgated in 2005 but was subsequently vacated by the DC Circuit Court of Appeals and remanded to the U.S. Environmental Protection Agency. However, it remains in effect until a replacement is available; presumably, this will be CSAPR.

oxide emissions that are similar to, but somewhat less stringent than, those under the Cross-State Air Pollution Rule (CSAPR).[5]

POLICY SCENARIOS

This analysis considers three different carbon tax rates in combination with each of the baseline scenarios described above. The carbon tax is expressed as a tax on emissions of CO_2. Each scenario imposes a trajectory of CO_2 tax rates that grows at 5 percent annually in real terms. The tax rates assumed in 2020 under the three scenarios are $10, $25, and $40 per ton. (All dollar amounts are in 2009$.)[6]

Results

The results of this modeling analysis reveal that the level of a carbon tax and realizations of natural prices and electricity demand will have important effects on electricity prices, carbon tax revenue, electricity production, and emissions of CO_2. They also show how electricity markets in different regions of the country are affected under the various scenarios. Each of these factors is discussed in more detail below.

NATIONAL ELECTRICITY PRICES

Figure 2 shows the national average retail electricity price projections under different carbon tax scenarios and for both baselines. The solid lines represent those scenarios that use AEO 2011 assumptions for electricity demand growth and natural gas supply and the dashed lines represent the AEO 2009 scenarios. As projected prices increase with the level of the carbon tax, they also increase over time as the carbon taxes grow in real terms. The results also show that imposing the $10 tax trajectory on AEO 2011 assumptions yields prices approximately equal to AEO 2009 projections without a carbon tax. In other words, the electricity price reductions projected due to secular changes in natural gas supply and electricity demand between the AEO11 BL scenario and the AEO09 BL scenario (solid black versus dashed black lines in the graph) is almost exactly undone by imposing the $10 tax trajectory on the AEO 2011 assumptions (solid red line). In fact, at every tax level, the electricity price increments from the next lower tax level are almost exactly offset by recent secular trends.

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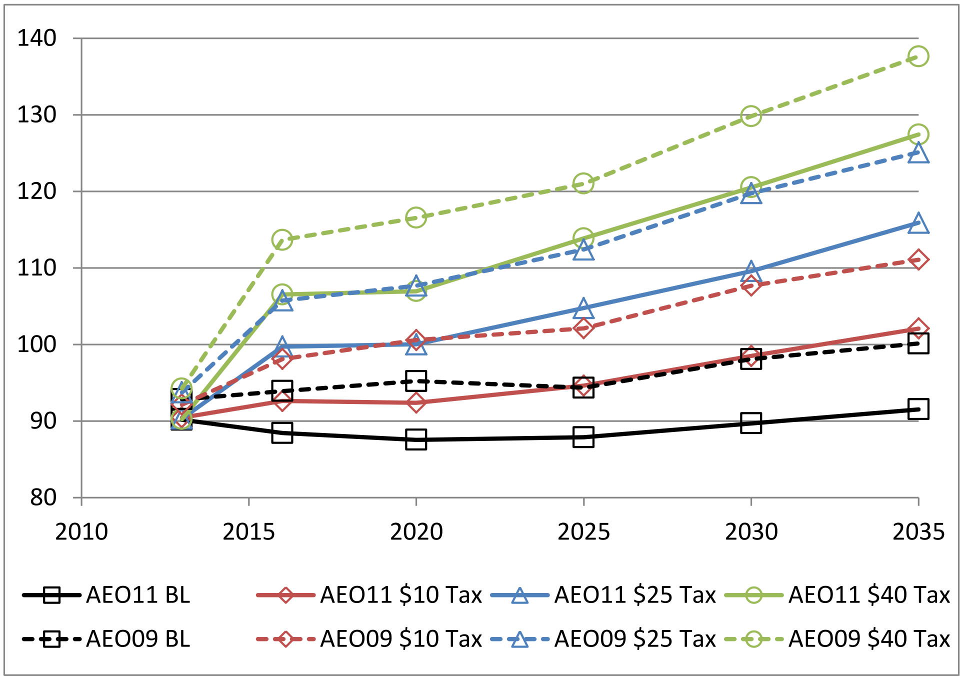
[5] As of this writing, CSAPR has been stayed by the DC Circuit of the U.S. Court of Appeals pending judicial review.

[6] In all of these scenarios, we assume that revenues from the tax are returned in a lump-sum manner to households; in other words, they do not affect the fiscal position of the United States or the behavior of consumers in electricity markets.

Figure 2. National Average Retail Electricity Prices ($/MWh)



CARBON TAX REVENUES

The carbon tax revenues are clearly sensitive to underlying assumptions about natural gas supply and electricity demand growth, and they are uniformly lower when natural gas is less expensive and when demand growth is lower. Variability of carbon fee revenues with respect to these factors depends on the level of the fee. Figure 3 illustrates that for a $10 tax trajectory, tax revenues vary depending on assumptions about secular trends by a few billion dollars per year. With the higher $40 tax trajectory, tax revenues vary by as much as $25 billion per year, which is equal to roughly 30 percent of total annual tax revenue in the electricity sector. Another way to think about the variability is on a cumulative basis. Table 1 shows that the net present values of total carbon tax revenues over the 20-year time horizon from 2016 through 2035 vary by just over 14 percent for the $10 tax trajectory and by close to 27 percent for the $40 trajectory.

Figure 3. Annual Carbon Tax Revenues from the Electricity Sector (billions of 2009$)

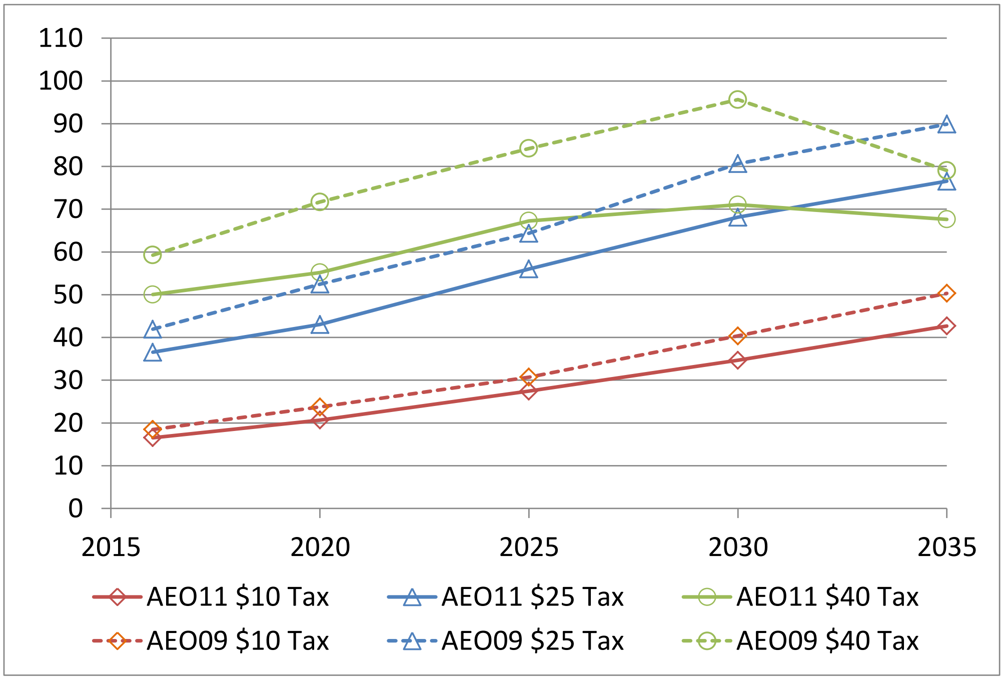


Table 1. Net Present Value of Carbon Tax Revenues from the Electricity Sector

	Net Present Value in 2016		
Baseline scenario	$10 Tax scenario	$25 Tax scenario	$40 Tax scenario
AEO 2011 (billions of 2009 $)	337.8	680.0	788.1
AEO 2009 (billions of 2009 $)	387.2	800.3	997.6
Percentage difference (%)	14.6	17.7	26.6

Annual carbon tax revenues also change over time as a result of changes in the tax rate and emissions profile. For the $10 and $25 tax trajectories, carbon tax revenues increase over time as the level of the tax rises. For the $40 tax trajectory, tax revenues increase until 2030 and then start to decline. Under the low demand and gas price projections of AEO 2011, revenues increase only slightly after 2025, and the decline after 2030 is gradual. With the higher gas price and demand growth in the AEO 2009, both the increase in tax revenues up until 2030 and the subsequent rate of decline are much higher. The decline in revenues is a direct result of the erosion of the CO_2 tax base as emissions fall faster than the tax rate grows, due to changes both in total generation and in the share of generation from fossil generators. The next section explores the effect of the policies on generation mix in more detail.

This analysis focuses only on the electricity sector, but a carbon tax would also generate revenues from other sectors of the economy. A previous analysis of an economy-wide cap-and-trade program (EIA 2009a), which yields a carbon price trajectory a little higher than the $25 tax trajectory analyzed here, suggests that nonelectricity sectors would provide additional tax revenues of $87.0 billion in 2016, which would increase to $234.2 billion in 2030. The analysis projects carbon tax revenues from the electricity sector of $51.7 billion in 2016, which would increase to $83.6 billion in 2026 and then fall to $72.1 billion in 2030. This suggests that the electricity sector would provide 24 to 37 percent of total carbon tax revenues. As shown in Figure 2, annual tax revenues from the electricity sector under the $25 tax trajectory can vary by approximately 15 to 20 percent. This indicates that the total revenue from a carbon tax could vary by roughly 4 to 7 percent as a result of changing forecasts of natural gas prices and electricity demand.

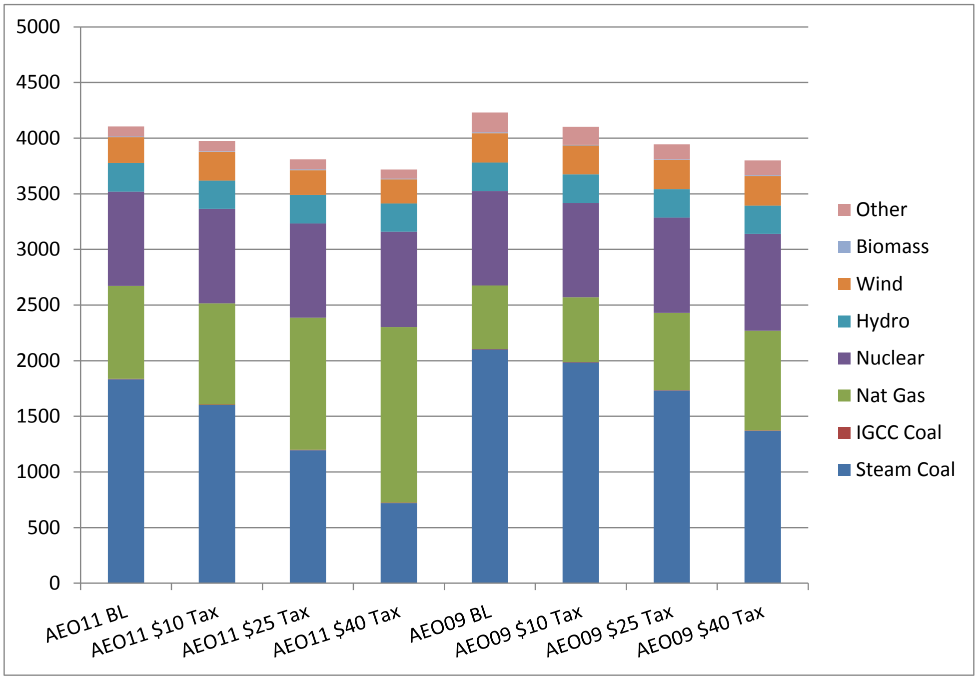
GENERATION TECHNOLOGIES

Both fuel prices and carbon taxes have important effects on how electricity is produced. Figures 4 and 5 show the mix of fuels and technologies used to generate electricity under each of the scenarios in 2020 and 2035, respectively. Under the AEO 2011 low gas price assumptions, natural gas plays a bigger role in electricity generation than under the 2009 cases. Under both assumptions about secular trends, that role grows over time and as the tax level increases. The relative shares of natural gas versus coal are a function of the relative prices of the two fuels, which in turn depend on their CO_2 emissions rates and the level of the carbon tax. In 2020, imposing a $25 tax on CO_2 with the AEO 2009 high gas price assumptions results in relative shares of coal and gas that are similar to those that occur in the AEO 2011 baseline scenario.

Under the $40 carbon tax trajectory, steam coal generation is driven to a small share by 2035, especially under the AEO 2011 lower gas price assumptions.[7] The overall share of fossil generation in 2035 under the $40 tax is 48 percent under AEO 2011 assumptions, but is only 42 percent under the 2009 assumptions. This diminution in the tax base is the reason for the rapid decline in CO_2 tax revenues in that scenario. As the carbon tax rate increases across scenarios and over time, so too does the role of nonemitting generation, including nuclear and wind. Also, the higher electricity demand growth assumptions in the 2009 case mean that the absolute level of nonemitting generation is higher, particularly by 2035.

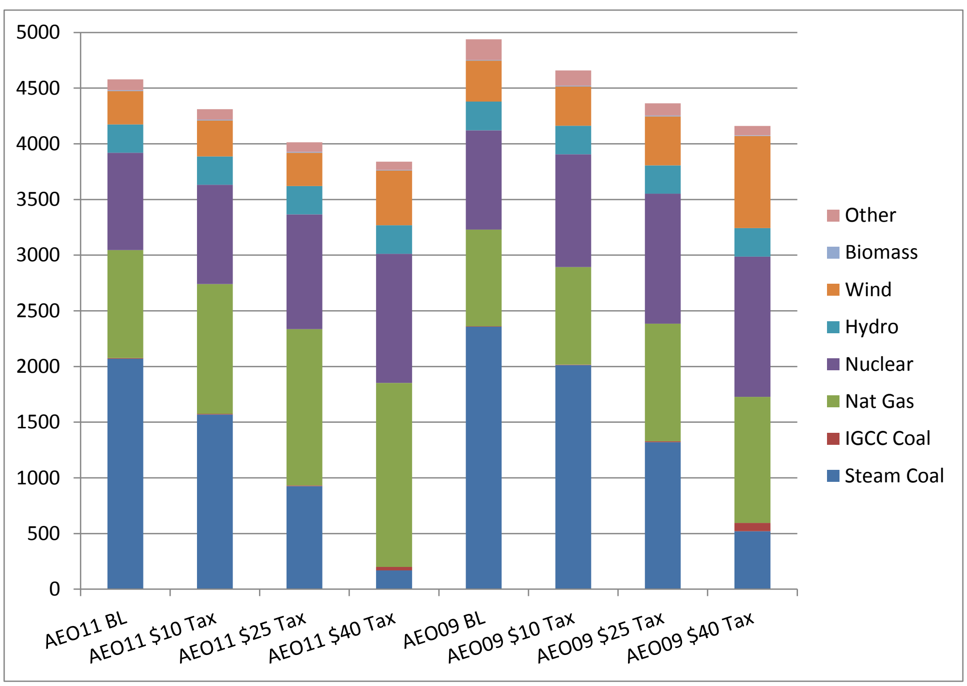
[7] Haiku does not simulate retrofit carbon capture and storage investments on existing coal boilers. By 2035, that technology might be commercially viable and would tend to increase the share of surviving coal boilers.

Figure 4. Electricity Generation in 2020 (TWh)



Note: IGCC, integrated gasification combined cycle.

Figure 5. Electricity Generation in 2035 (TWh)

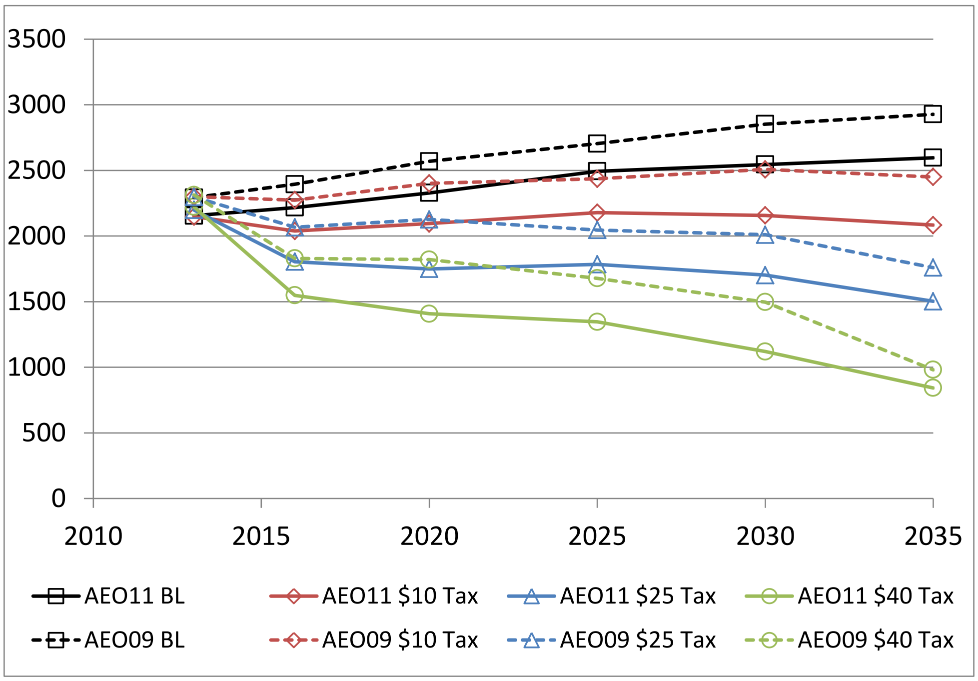


Note: IGCC, integrated gasification combined cycle.

CO_2 EMISSIONS

The effects of the different scenarios on emissions of CO_2 from the electricity sector are displayed in Figure 6. Changes in secular trends between AEO 2009 and AEO 2011 result in a lower projected trajectory of CO_2 emissions. Under the more recent assumptions, CO_2 emissions decline slightly over time under the $10 tax trajectory (red solid line) and by more than 25 percent with the $25 tax level (blue solid line). The difference in emissions between the AEO 2009 and 2011 baseline cases is equivalent to the effect of imposing the $10 tax trajectory on the AEO 2009 case. The combination of lower gas prices, more end-use energy efficiency, and the slower-than-expected recovery from the recession has had an important effect on lowering the future emissions of CO_2 relative to levels that were anticipated in early 2009.

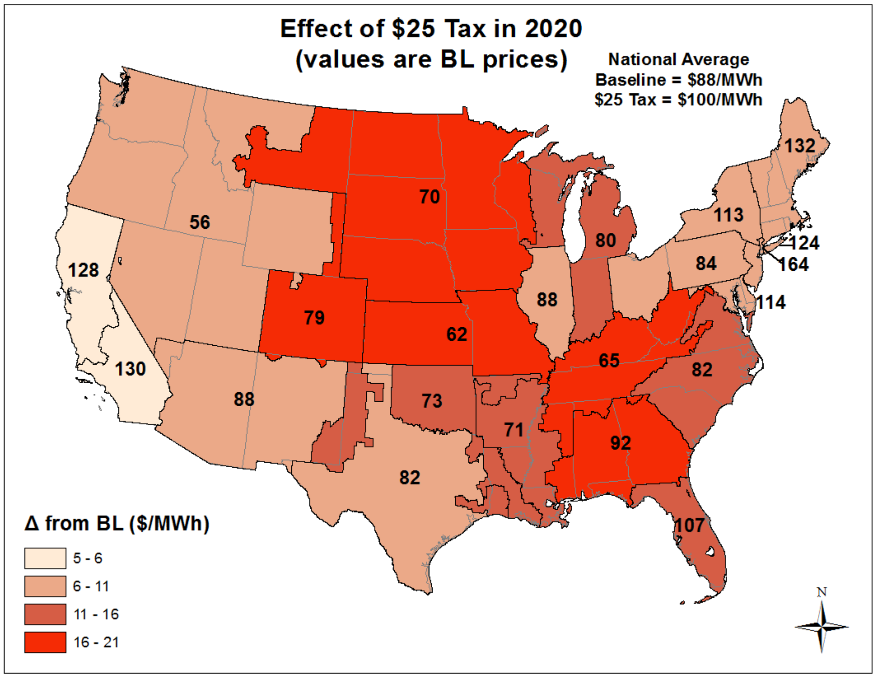
Figure 6. National CO_2 Emissions from Electricity Generation (million tons)



REGIONAL OUTCOMES

The national average retail electricity price trajectories shown in Figure 1 mask some important regional differences. Because the existing fleet of electricity generating capacity is heterogeneous across different regions of the country, and because consumers in different regions face different forms of electricity market regulation, the retail price effects of a CO_2 tax vary regionally. The price effects of the $25 tax in 2020, under the AEO 2011 assumptions, are shown in Figure 7. The number within each region is the regional retail electricity price ($/MWh) under the AEO11 baseline scenario, whereas the color of each region represents the price change due to the $25 carbon tax.

Figure 7. Regional Retail Electricity Prices



Note: MWh, megawatt-hour.

The largest price increases occur throughout the Plains, Appalachia, parts of the Midwest, and to a lesser extent the Southeast. These are the most coal-intensive regions of the country, some of which generate more than 70 percent of their electricity from coal in AEO11 BL. Because coal is more CO_2-intensive than other generation fuels, these regions face the largest tax burden, which is passed through to consumers in higher retail electricity prices. The regions of the country that rely less on coal to generate electricity, such as the Northeast, the West, and Texas, see smaller price effects. These regional differences in price changes have the interesting effect of generally leveling retail electricity prices across the country. The regions that experience the largest price increases, as shown by the boldest coloring in Figure 7, have prices below the national average in the baseline and continue to experience prices below the national average under the $25 carbon tax. Conversely, the regions with the highest baseline electricity prices, such as the Northeast and California, see only small to moderate price increases under the $25 tax. This results in smaller regional price disparities than exist without a tax on CO_2.

Conclusions

As the federal government looks for ways to address the fiscal challenges posed by large and growing federal deficits, discussions about a carbon tax have quietly emerged to identify a potentially important source of new revenue. A carbon tax has much to recommend it, particularly because it provides an incentive to reduce emissions that are damaging to the environment and because it could be used to displace future taxes on investment income or labor, forms of economic activity that tend to be discouraged by increased taxes.

To understand the role that a carbon tax might play in fiscal reform, it is important to understand how much revenue such a tax might generate. A substantial fraction of the tax revenue from a carbon tax will come from the electricity sector. In this issue brief, we show that the amount of electricity-related revenue from a carbon tax will depend importantly on secular trends with respect to electricity demand growth and natural gas supply. The variability of the tax revenues with respect to those trends depends on the level of the tax. Under a $10 tax trajectory, annual electricity sector revenues vary by only a few billion dollars. If the $40 tax trajectory is adopted, revenues vary by up to 30 percent. Overall, the net present value of tax revenues from the electricity sector over the 20-year horizon beginning in 2016 varies from close to $350 billion to roughly $1 trillion, with even larger revenues expected from outside the sector with an economy-wide tax, as electricity is responsible for well under 50 percent of total carbon emissions in the United States.

The carbon tax has an important impact on the price of electricity paid by consumers. In this analysis, we show that the effects of recent secular trends toward lower natural gas prices and reduced electricity demand growth almost perfectly offset a carbon tax of about $10 per ton.

The political economy of a carbon tax proposal will depend importantly on what happens to electricity prices locally. Our analysis suggests that some of the regions that have low electricity prices currently will tend to be the hardest hit, in part because of their heavy reliance on coal. Nonetheless, for moderate carbon tax rates, these regions will continue to have low electricity prices, and the carbon tax tends to reduce existing price differences across the regions.

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