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DISCUSSION

A Proximate Mirror:

Greenhouse Gas Rules and Strategic Behavior under the US Clean Air Act

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RESOURCES FOR THE FUTURE

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Abstract

The development of climate policy in the US mirrors international developments, with efforts to initiate a coordinated approach giving way to jurisdictions separately taking actions. The centerpiece of US policy is technology-based regulation in the electricity sector that identifies an carbon emissions rate standard (intensity standard) for each state, but leaves to states the design of policies including potentially the use of technology policies, emissions rate averaging or cap and trade. Differences in policies among states within the same power market could promote predatory behavior resulting in a geographic shift in generation and investment in new resources. This paper examines the coordination problem using a detailed partial equilibrium model. We demonstrate that leading jurisdictions have available a rich set of design options that can protect them against strategic predation and in fact give them opportunities to proactively advance climate goals to the economic detriment of laggards.

Key Words: climate policy, efficiency, equity, Clean Air Act, coal, compliance flexibility, regulation, states

JEL Classification Numbers: K32, Q54, Q58

Contents

A Proximate Mirror: Greenhouse Gas Rules and Strategic Behavior under the US Clean Air Act

Dallas Burtraw, Karen Palmer, Sophie Pan and Anthony Paul*

1. Introduction

The development of climate policy in the United States mirrors international developments, with efforts to initiate a coordinated approach giving way to regimes in which jurisdictions are separately taking actions with differing policy designs. Independent policy design introduces opportunities for strategic behavior that can lead to leakage of economic activity and emissions, and an increase in overall costs or emissions or both. Jurisdictions that exercise policy leadership in the stringency or design of their policy may be especially vulnerable to strategic interaction. Their costs may rise due to the policy choice of neighboring jurisdictions, which in turn may benefit from predatory behavior, undermining the prospect for climate policy. Using the US electricity sector as a laboratory we demonstrate that leading jurisdictions have available a rich set of design options that can protect them against strategic predation and in fact give them opportunities to proactively advance climate goals to the economic detriment of laggards.

US climate policy is taking shape through the Climate Action Plan announced by President Obama in June 2013. The plan encompasses improved motor vehicle standards, additional appliance efficiency standards, and regulation of greenhouse gases from a variety of sources. It includes an inflexible emissions rate standard for new fossil-fired facilities comparable to that of a new natural gas combined cycle unit. This standard effectively requires the application of carbon capture and storage at new coal-fired facilities; however, few new coal-fired facilities were likely to be built in the near term. The centerpiece is the Clean Power Plan (CPP) and is aimed at existing sources in the electricity sector, which are responsible for about 38 percent of total national emissions. The CPP introduces regulations under the federal Clean

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Air Act aimed at reducing emissions in the electricity sector by 30 percent from 2005 levels by 2030, with most of the reductions achieved by 2020.

The CPP embodies the familiar framework of cooperative federalism in US environmental law. It establishes a technology based carbon emissions rate standard of performance (intensity standard) for each state, but leaves to states the responsibility for planning, implementation and enforcement to achieve the standard. States are granted remarkable flexibility including the possibility of using technology policies or economic incentives such as emissions rate trading (averaging), cap and trade, or taxes to achieve the performance standard.[1] States may develop multi-state plans to average emissions rates across states, or adopt regional cap and trade. The US Environmental Protection Agency (EPA) will issue its final rule in the summer of 2015 and states will have 1 year to prepare a plan, with possible extensions of up to 2 additional years for states developing multi-state plans. Initial compliance is expected in 2020.

The recent change of course in US climate policy is abrupt. In 2009 the US House of Representatives passed comprehensive national climate legislation that would have introduced economy-wide cap and trade as a centerpiece. The legislation did not come to a vote in the Senate and its demise in 2010 cast a shadow on the prospects for climate policy in the US. Three years later, policy of similar stringency began taking shape. In the electricity sector, the centerpiece is a bottom-up process where state jurisdictions make separate choices about how they will comply.

The change in course within the US somewhat parallels changes that have occurred in international climate negotiations. The Conference of the Parties to the international negotiations met in Berlin in 1995 to launch the process that eventually led to the Kyoto Protocol in 1997 and introduced an ambitious obligation on signatories. The refusal of the US to ratify the treaty and the disaffection of other parties undermined that coordinated approach. Strategic and competitive interactions have influenced the international debate. If one were to imagine the Kyoto Protocol as a cooperative solution to a strategic problem, it shared a characteristic inherent to cooperative game theory in general, that the solution did not specify incentive compatible steps to achieving the outcome.

[1] In principle states might use a cap-and-trade policy to achieve the emissions rate target, but EPA has given states explicit ability to convert their emissions rate target to an emissions mass target that would facilitate the use of cap and trade.

Internationally, the current potential for optimism resides in the prospects for a bottom-up process of nationally determined contributions. This pledge and review process among nations more closely resembles a non-cooperative solution. The theoretical question with relevance internationally and in the US is whether this type of bottom-up approach can solve the difficult coordination challenge to achieve an outcome that is effective.

One step to solving the challenge to date appears to involve the proliferation of technology policies, which are often described as enabling or complementary to the emergence of comprehensive approaches. For example, in the EU, renewable policies have contributed to low prices in the emissions trading system helping to enable the adoption of more stringent emissions targets.[2] In the US, the stringency of the CPP is based on findings about technical feasibility to reduce carbon emissions drawing on the variety of technology policies already in place in the states.[3] The economics literature has broadly characterized these policies as a potentially inefficient way to achieve emissions reductions.[4] However, we suspect that if a bottom-up climate policy is going to succeed, perhaps eventually leading to a coordinated and comprehensive solution, it is likely to require the learning and coalition building that is achieved through such an incremental process (Keohane and Victor 2013).

In the US the coordination challenge is perhaps simplified because the EPA has determined the stringency of state goals, while there is nothing comparable internationally. However, the nearly absolute flexibility in policy design under the CPP provides states with a monumental coordination challenge as complex as that at the international level. Emerging as a central question for states in the US is the form and reach of their plans. Form pertains to the policies that will be enacted in their state – for example technology standards, incentives for renewables and energy efficiency, cap and trade, etc. Reach pertains to the interaction of states with neighboring states. Multi-state plans would allow states to capture the efficiency of harmonizing policies across diverse situations. Even more important, however, is the overlap between compliance activities at the state level and the power planning regions and markets that cover multiple states and sometimes divide states. As we describe below, the policy designs chosen by states may interact with power markets to lead to unintended geographic shifts in

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[2] In California, approximately 83 percent of the emissions reductions necessary to achieve the state's climate goals for 2020 will be achieved by regulatory standards and measures.

[3] Currently 29 states have policies promoting renewable energy and 24 have policies promoting energy efficiency.

[4] Fischer et al. (2013).

electricity generation and investment in new facilities, resulting in increased costs, emissions or both. States might respond to decisions of their neighbors to their own benefit and at the expense of their neighbors. Even if states chose the same design, the variation in stringency among states that is inherited from the EPA could lead to such negative outcomes.

This paper examines the coordination problem in the context of the US electricity sector using a detailed partial equilibrium model of operations and investment through 2035 to examine interactions among state policies and power markets. We compare an emissions rate standard with emissions cap and trade. Under some forms of cap and trade, the interaction of these policies can provide substantial cost advantages to the jurisdiction with an emissions rate standard, leading to shifts in operation and investment into that region. Because the emissions rate standard does not place a cap on total emissions, this policy combination can lead to an increase in emissions overall compared to the outcome if both regions have an emissions rate standard. However, under other forms of cap and trade, the interaction can lead to zero leakage by using targeted output based allocation to mimic the incentives that are created under the emissions rate standard. Recognizing that this equivalence is possible, one can therefore imagine negative leakage with operations and investment flowing into the region with an emissions cap and leading to a decrease in emissions over the entire interstate region, which we show is achievable.

The ability of states to use targeted output based allocation to preserve the level of operation and investment that would occur if they used the emissions rate standard means that states can address the strategic issues that are introduced by using emissions cap and trade, while achieving the many administrative advantages of that approach compared to an emissions rate standard. Costs under these outcomes vary under different policy combinations between neighboring jurisdictions and are lowest under a coordinated approach. Perhaps as importantly, the distribution of costs among consumers, incumbent generators and new investors also vary.

In the next section of this paper we describe the US policy context in more detail and review the international literature on the interaction between emissions rate (intensity) standards and cap and trade. In section 3 we introduce the model and describe the scenarios that reflect state policy options. In section 4 we describe results including the possibility for perverse outcomes and strategic predatory behavior, and defensive responses to prevent this outcome. Section 5 provides a concluding discussion.

2. Policy Background and Literature

EPA issued the preliminary version of the CPP in June 2014. The rule establishes an *adjusted* emissions rate performance standard for each state. The numerator of the emissions rate calculation includes emission from existing electricity generating units (built before 1/8/2014) of a minimum size and utilization. The denominator includes energy production from these sources and production from existing and new nonemitting resources, avoided generation attributable to energy efficiency and 6 percent of generation from existing nuclear units.[5]

The stringency of the emissions rate standard is derived from technical findings about the opportunity for emissions rate reductions from four "building blocks" in each state. These include increased efficiency at coal-fired units, anticipating a 6 percent improvement in heat rates; more effective use of existing natural gas combined cycle units, anticipating 70 percent utilization of capacity; increased renewable generation based on accomplishments already achieved among states in each region, and preservation of nuclear units now in operation; and expanded energy efficiency programs ramping up to a 1.5 percent annual incremental savings rate. These measures are used to determine the emissions rate targets for individual states, which can vary by a factor of 6 depending on the situation in the states.

The Climate Action Plan and the CPP encourage flexible implementation.[6] The cost savings from a flexible approach to implementation could be substantial, especially if implemented on a regional or national basis. Burtraw et al. (2012) and Linn et al. (2014) show that a tradable performance standard for reducing CO_2 emissions from the electricity sector can cost 70 to 90 percent less than a traditional (nontradable) performance standard.

States are also given the option of converting the emissions rate target to an emissions budget (mass-based) goal that would simplify many aspects of implementation including evaluation of energy efficiency programs and interstate collaboration. In principle, conversion to an emissions budget is achieved by multiplying the emissions rate standard (lbs CO_2/MWh) by the activity level (MWh); in practice the determination of the appropriate activity level remains

[5] An important issue on which EPA seeks comment is whether and how new emitting sources should be treated.

[6] In a memorandum to EPA in June 2013, President Obama articulated the political directive to "ensure, to the greatest extent possible, that [EPA] … develop approaches that allow the use of market-based instruments, performance standards, and other regulatory flexibilities; [and] ensure that the standards enable continued reliance on a range of energy sources and technologies." See: http://www.whitehouse.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards (accessed December 20, 2014).

in debate and is one of the many issues to be clarified in the final rule. [7] States are not required to adopt any specific measure as elements of their compliance strategy however state plans must identify the compliance activities that will be used to achieve their goal, and identify corrective measures as a backstop if the actual reported emissions deviate substantially from the goal over the next decade.

A central issue for states is how measures taking in their state will interact with those in other states. For example, double counting might occur if one state provided incentives for renewable projects (or energy efficiency) that were built in another state. The first state might want to claim credit in its emissions rate calculation in order to justify the investment, while the second state could point to an observable reduction in its emissions rate. EPA has sought comment on how to structure guidelines to solve this challenge. Further, state emissions rate targets differ in stringency, which could complicate interstate collaboration. The CPP requires a blended (average) emissions rate to apply uniformly across states that comply on a regional basis, but this may strictly disadvantage the state that otherwise would have a higher standard. Michel and Nielsen (2014) describe emissions rate trading weighted on the basis of the relative standards in each state, which would preserve the incentives associated with the state's own standard but allow for regional compliance.

The subject of this paper is another way that state policies will interact – through the movement of power and new investment in the electricity market. A key characteristic of an emissions rate standard is that along with introducing a price on emissions it provides an incentive for production because the firm earns emissions credits per unit of production (Fischer 2003). If the facility's emissions rate is less than the standard, the facility has a net credit from the *difference* between its observed performance and the standard. If two states have different emissions rate standards, incentives may exist to shift generation and investment to the jurisdiction with a less stringent standard. The shift may lead to the utilization of different fuels and technologies, leading to an increase in emissions of CO_2 as well as changes in the location and magnitude of other pollutants including sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which provide many of the benefits of the rule.

States are given the option of converting the emissions rate target to an emissions budget (mass-based) goal that would simplify many aspects of implementation including evaluation of

[7] EPA offered some examples of how such a conversion might be done in.

energy efficiency programs and interstate collaboration. However, differences in production incentives would be even greater if one state chooses to use conventional cap and trade without a production incentive and a neighboring jurisdiction retains its emissions rate standard. In effect, the production incentive in the capped region is zero; for example, if emissions allowances are distributed through an auction then facilities must purchase all of their allowances. Even if a cap and trade program distributes emissions allowances for free, as was the practice under the Title IV Acid Rain Program for SO_2 emissions, there typically does not exist a production incentive because the volume of allowances distributed to facilities does not depend on its generation activity. In this case because emissions in one jurisdiction are capped, but not capped in the neighboring jurisdiction, then incentives exist for a shift in the operation of existing generation resources and investment in new resources to the jurisdiction that does not cap emissions (Bushnell et al. 2014).

A similar argument characterizes the international dialogue about linking climate policies in different nations. Marschinski (2008) suggests that linking a program with an emissions cap with one with an intensity target would create incentives for emissions leakage with negative environmental consequences.

The policy strategy we investigate is the incorporation of a production incentive in the design of an emissions constraint. One way this can be accomplished is through the allocation of emissions allowances on the basis of economic activity (electricity generation). First we evaluate a scenario in which all states use a tradable emissions rate policy to comply with the emissions rate target assigned to states under the CPP. We compare this scenario with scenarios in which policies vary across regions. We consider the interaction of the emissions rate policy in the rest of the nation with various formulations of an emissions budget (cap and trade) policy in the upper Midwest. We find the possibility for leakage to be significant, depending on the form of the cap and trade program. In one case we imagine the emissions allowances in the cap and trade policy are auctioned with revenues leaving the electricity sector (equivalent to an emissions tax), resulting in leakage of generation and emissions to other regions, and an increase in overall emissions. In another case we imagine the revenues remain in the electricity sector and are directed to consumers through their local distribution company, as proposed in 2009 in the Waxman-Markey proposal for national level cap and trade, and again we find substantial leakage and increase in emissions. In other cases we imagine targeted production incentives (output based allocation) that reward utilization of specific technologies, and we show that negative leakage can occur with a decrease in total emissions compared.

In general, the production incentive leads to more production from the targeted technology, but it is informative to consider an example where that might not happen. If there were only one type of technology and an emissions cap was introduced that reduced emissions, and if this cap was binding, the only way it could be achieved would be through a proportional reduction in generation from these facilities. With a homogenous set of emitting technologies, the emissions cap would determine the amount of generation coming from these generation resources. If targeted updating output based allocation were used to provide a production incentive to these sources, the consequence would be to drive up allowance prices with no change in the generation mix (Rosendahl and Storrøsten 2011; Bushnell and Chen 2012). If a reduction in generation from emitting sources occurs the system might be balanced through reduced consumption or through expanded use of non-emitting resources in the region, or it might come from an increase in the import of power from neighboring states. The latter case might result in an increase in emissions if fossil units were used to provide that increment in generation, leading to emissions leakage and an increase in total emissions.

However, one of the ways that output based allocation can be effective is by directing the production subsidy to the promotion of greater use of and investment in low or non-emitting resources within the regulated region (Fischer 2003; Burtraw et al. 2006). The difference between the demand for electricity services and generation from the emitting technology could come from nonemitting sources. Further, the CPP treats energy efficiency as a nonemitting resource and some states may prefer to direct allowance value to energy efficiency as has been done in the northeast Regional Greenhouse Gas Initiative cap and trade program, where approximately two-thirds of the value of emissions allowances is directed to investments in energy efficiency.

The ability of states to use targeted output based allocation to preserve the level of operation and investment obtained under an emissions rate standard means that states can address strategic issues introduced by using emissions cap and trade while achieving the administrative advantages of that approach. Economic costs under these outcomes vary under different policy combinations and are lowest under a coordinated approach (Holland 2012). Perhaps as importantly, the distribution of costs among consumers, incumbent generators and new investors also vary because the production incentive has different effects on the variable cost of the marginal electricity generator under various scenarios.

3. Model and Scenario Descriptions

We use a highly parameterized electricity market simulation model to characterize the response of the electricity system to a variety of potential climate policies undertaken by states, and their regional interactions of those policies.

3.1. The Haiku Electricity Market Model

The simulation modeling uses the Haiku electricity market model,[8] which is a partial equilibrium model that solves for investment in and operation of the electricity system in 22 linked regions of the continental United States, from 2013 out to the year 2035. Each simulation year is represented by three seasons (spring and fall are combined) and four times of day. 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. Supply is represented using 53 model plants in each region, including various types of renewables, nuclear, natural gas, and coal-fired power plants. Assumed levels of power imports from Mexico and Canada are held fixed for all scenarios. Thirty-nine of the model plants in each region aggregate existing capacity according to technology and fuel source from the complete set of commercial electricity generation plants in the country. The remaining 17 model plants represent new capacity investments, again differentiated by technology and fuel source. Each coal model plant has a range of capacity at various heat rates, representing the range of average heat rates at the underlying constituent plants.

Operation of the electricity system (generator dispatch) in the model is based on the minimization of short-run variable costs of generation, and a reserve margin is enforced based on margins used by the Energy Information Administration in the Annual Energy Outlook (AEO) for 2013 (EIA 2013). Fuel prices are benchmarked to the AEO forecasts for both level and supply elasticity. Coal is differentiated along several dimensions, including fuel quality and

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[8] In terms of its sectoral and geographic coverage, Haiku is comparable to several other national electricity-sector models, including the Integrated Planning Model (IPM, owned by ICF consulting and the model of record for EPA), ReEDS (maintained at the National Renewable Energy Laboratory), and the Electricity Market Module of the National Energy Modeling System (NEMS, maintained by the Energy Information Agency). Haiku, IPM, and ReEDS model the electricity sector and partially model factor markets, like fuel, for the continental United States. NEMS also links its electricity sector model to the entire economy and models all fuel markets. For more information about the Haiku Electricity Market Model, see Paul et al. (2009).

content and location of supply, and both coal and natural gas prices are differentiated by point of delivery. The price of biomass fuel also varies by region depending on the mix of biomass types available and delivery costs. Coal, natural gas, and biomass are modeled with price-responsive supply curves, so these fuel prices respond to endogenous changes in demand for these fuels. Prices for nuclear fuel and oil, as well as the price of capital and labor, are held constant.

Investment in new generation capacity and the retirement of existing facilities are determined endogenously[9] for an intertemporally consistent (forward-looking) equilibrium, based on the capacity-related costs of providing service in the present and into the future (going-forward costs) and the discounted value of going-forward revenue streams. Existing coal-fired facilities also have the opportunity to make endogenous investments to improve their efficiency. Discounting for new capacity investments is based on an assumed real cost of capital of 7.5 percent. Investment and operation include pollution control decisions to comply with regulatory constraints for sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury, hydrochloric acid (HCl), and particulate matter (PM), including equilibria in emissions allowance markets where relevant. All currently available generation technologies as identified in AEO are represented in the model, as are integrated gasification combined cycle coal plants with carbon capture and storage and natural gas combined cycle plants with carbon capture and storage. Ultra-supercritical pulverized coal plants and carbon capture and storage retrofits at existing facilities are not available in the model. The model does not capture the role in a plant's retirement decisions of complex fuel contracts. Although short-term contracts are common in coal markets, long-term contacts could play an important role in retirement decisions. If long-term contracts incentivize some plants to remain in operation, this modeling omission likely leads to an overestimate of coal-fired retirement projections and potentially of other new investment. Price formation is determined by cost-of-service regulation or by competition in different regions corresponding to current regulatory practice. Electricity markets are assumed to maintain their current regulatory status throughout the modeling horizon; that is, regions that have already moved to competitive pricing continue that practice, and those that have not made that move remain regulated.[10] The

[9] Investment (in both generation capacity and pollution controls) and retirement are determined according to cost-minimization. This fails to account for the potential Averch-Johnson effect (1962), which tends to lead to overinvestment in capital relative to fuel and to raise costs.

[10] There is currently little momentum in any part of the country for further electricity market regulatory restructuring. Some of the regions that have already implemented competitive markets are considering reregulating parts of the industry.

retail price of electricity does not vary by time of day in any region, though all customers in competitive regions face prices that vary from season to season.

The model requires that each region have sufficient capacity reserve to meet requirements drawn from the North American Electric Reliability Corporation. The reserve price reflects the scarcity value of capacity and is set just high enough to retain just enough capacity to cover the required reserve margin in each time block. In competitive regions, the reserve price is paid within a capacity market framework within each time block to all units that generate electricity and to those that provide additional capacity services. We do not model separate markets for spinning reserves and capacity reserves. Instead, the fraction of reserve services provided by steam generators is constrained to be no greater than 50 percent of the total reserve requirement in each time block.

3.2. Modeling Scenarios

We use this policy laboratory to analyze and compare a tradable emissions rate performance standard program and various forms of cap and trade in the electricity sector, and we examine the policy interaction across regions under various settings.

3.2.1. Baseline Scenario (BL)

The baseline includes all of the major environmental policies affecting the electricity sector. This includes the SO_2 trading program under Title IV of the Clean Air Act, the Regional Greenhouse Gas Initiative, the federal renewable energy production and investment tax credit programs, California's cap-and-trade program and all of the state renewable peformance standards and renewable tax credit programs. The baseline also includes the Mercury and Air Toxics Standards (MATS), which have been finalized by EPA and fully take effect in 2016 in our model. Finally, the baseline includes the Clean Air Interstate Rule (CAIR) in place of the Cross-State Air Pollution Rule (CSAPR), which was been struck down by the court and recently reinstated but nto in effect. This can be taken to represent a future regulation on SO_2 and NO_x.[11] The baseline is calibrated to the AEO (EIA 2013). All of the characteristics of the Baseline are held constant in the policy scenarios except for the Regional Greenhouse Gas Initiative and California's cap-and-trade programs, and otherwise as discussed below.

[11] Our previous modeling has shown only small changes to the electricity sector if CAIR is replaced with CSAPR when MATS is also in effect. Thus the choice between modeling these two SO_2 and NO_x regulations is of little significance in this analysis.

3.2.2. Policy Scenarios

We model six compliance regions, of which only one region (upper Midwest) has varying policy formulations across scenarios and the other five regions keep the same policies: rate-based tradable performance standard (Figure 1). The rate-based regions can have varying emissions in the electricity sector. In contrast, we calibrated upper Midwest to achieve identical CO_2 emissions trajectory through 2035 in every scenario. There is no banking or borrowing across years. These emissions and emissions rate targets are based on a careful representation of the CPP in the Haiku Electricity Market Model[12] and will result in emissions reductions close to EPA's estimation in the CPP. This regional policy configuration facilitates the study of emissions leakage.

Besides the regional differences, the policy treatments in all the scenarios have shared features across regions. The generator population to be covered by regulation are the same: all fossil-fired generators,[13] all renewables, new and at-risk[14] nuclear generators.[15] We also model energy efficiency (EE) programs[16] that are funded by a system benefit charge of 3$/MWh and yield end-use demand reduction at first-year cost of 180/MWh. For regions with rate-based policies, the demand reduction induced by EE programs counts towards compliance with their rate targets.[17]

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[12] We simulated 6 tradable performance programs in 6 compliace region with 22 HMR-level emissions rate targets that are translated from the CPP's state-level interim goal. The compliance period is 2020-2035. To determine annual emissions rate targets, we solve the model to represent the CPP with banking and borrow enabled over the decade 2020-2029; banking must be exhausted by 2029. Energy efficiency programs are included. Covered sources are all except existing hydro, 94% of existing nuclear, new NGCC. The emissions rate targets that are achieved are then used in the scearios we model.

[13] The CPP is ambiguous with respect to inclusion of new fossil sources.

[14] The CPP views an approximately 5.8 percent share of nuclear capacity as a reasonable proxy for the amount of nuclear capacity at risk of retirement (Clean Power Plan Proposed Rule: GHG Abatement Measures. Technical support document U.S. EPA 2014).

[15] The covered sources is the denominator in the CPP's formula for state goal plus new natural gas combined cycle

[16] The modeling of EE programs affects electricity prices and generation investment endogenously in a dynamic time frame. Energy savings has lifetime reductions persisting and decaying based on the partial-adjustment structure of the Haiku demand system. EE expenditures are allocated to consumers based on consumption shares. Approximately 5 percent of the lifetime energy savings associated with an investment in efficiency is realized in the first year.

[17] Factoring EE programs in assessing compliance is consistent with the the fourth building block in the Best System of Emissions Reductions used to construct states' emissions rate goals in the CPP: investment in energy efficiency to reduce electricity demand growth.

In our policy experiments on the upper Midwest, we compare four approaches with differences in the form of the policy and allocation of tax or allowance revenue. The first policy to be introduced is a rate-based tradable performance standard. The others have mass basis with difference in allocation of asset values: allocation to government, to consumers, and producers. These policies are correspondingly emissions tax, emissions budget with allocation to local distribution companies, and emissions budget with targeted updated output based allocation with several variants.

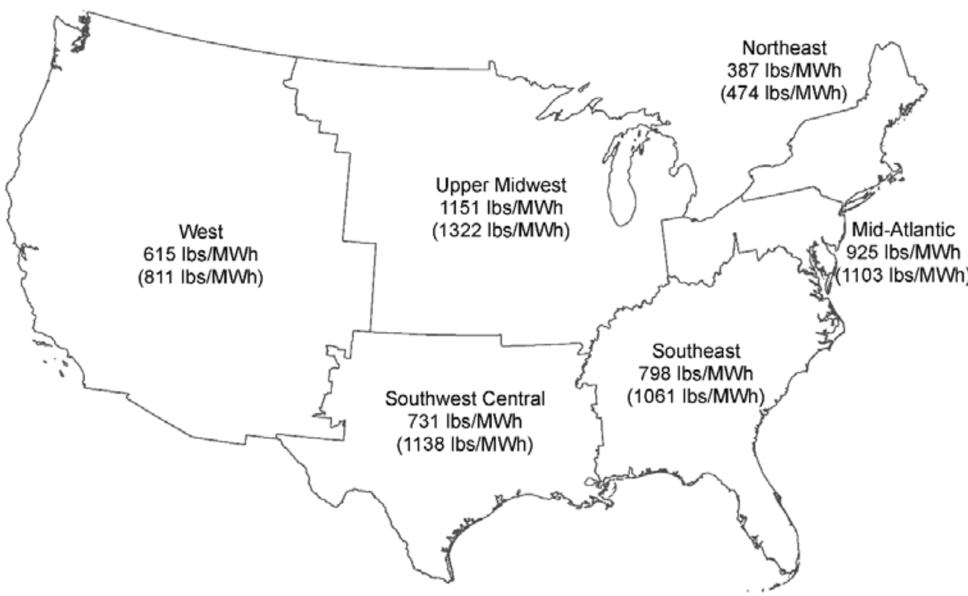


Figure 1. Map of Policy Regional Configuration with 2020 Emissions Rate Targets (with Baseline Emissions Rates)

Tradable Emissions Rate Performance Standard

Tradable emissions rate performance standard sets an emissions rate standard that the regulated sources must meet on average. Generators are obligated to surrender credits equal to their actual emissions rate multiplied by their annual generation and entitled to earn credits equal to the benchmark emissions rate multiplied by their annual generation. The net compliance obligation stems from the difference between the benchmark and actual emissions rates. We implement six regional emissions rate benchmarks that are calibrated to be equivalent to state emissions rate goals established in the CPP on average for the compliance period 2020-2035[18].

Emissions Tax

The emissions tax policy is implemented in upper Midwest where regulated generators pay carbon tax per ton of CO_2 emitted. The tax revenues accrue to government. This scenario is similar to a cap-and-trade with allowance auction when the emissions outcomes are calibrated to be equal to the same cap.

Emissions Budget with Allocation to Local Distribution Companies

Each region is apportioned a CO_2 emissions budget that is calibrated at the level achieved in tradable performance standard scenario. The allowance value raised is allocated to local distribution companies (LDCs) in proportion to their share of consumption. As regulated entities, LDCs are assumed to rebate the value to consumers through a credit on their electricity bills. Consequently, consumers are expected to pay lower retail electricity prices in this scenario than emissions tax scenario and react to lower prices by increasing consumption.

Emissions Budget with Targeted Updated Output Based Allocation

We experimented with several variant forms of regional emissions budget (cap-and-trade) policies with allowance value allocated to different sets of eligible generators based on ongoing updated output shares of all eligible sources. Under targeted updating, the allocation of allowance revenue is concentrated to a subset of all regulated entities. We describe three approaches in Table 1 and report results below.

[18] We utilized Haiku's representation of the CPP to derive the regional equivalent emissions rate targets for the complaince period 2020-2035.

Table 1 Policy Scenarios Using Targeted Updated Output Based Allocation (OBA)

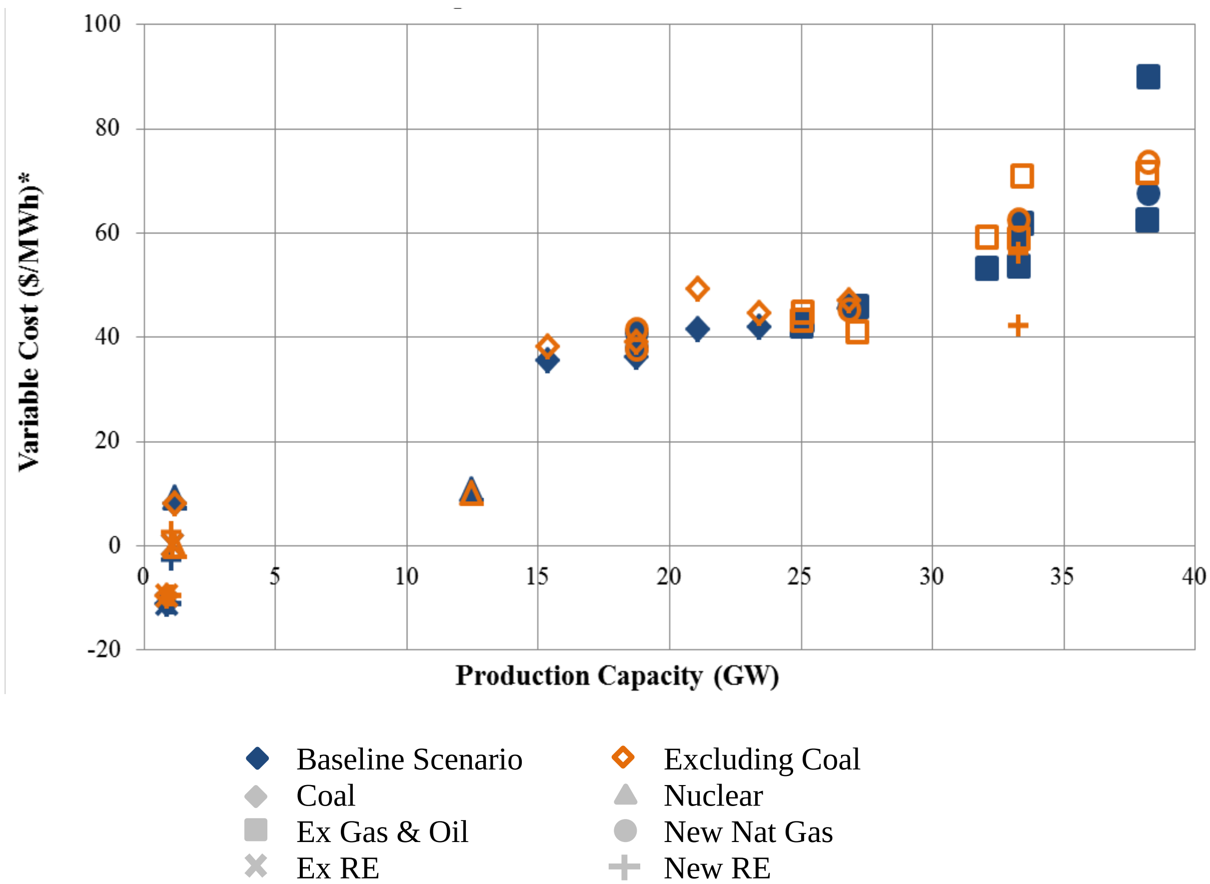
Generator Type		Regulated for Compliance	Eligible for Allowance Allocation		
			TPS / OBA-All	OBA-ExCoal	OBA-New NonEm
	Coal	x	x		
Fossil	Nat Gas	x	x	x	
	Oil	x	x	x	
	Existing Wind	x	x	x	
Renewables	Other Existing	x	x	x	
	New	x	x	x	x
Nuclear	Existing				
	New and at-risk	x	x	x	x
Hydro	All				

The policy scenario labeled "OBA-All" allocates the allowance value to the full set of covered (regulated) generators. This approach is conceptually similar to a tradable performance standard covering the same set of generators and the modeling of these two policies is identical if the emissions outcomes are constrained to be equal. In the scenario "OBA-ExCoal", coal is excluded from receiving allocation. Under the scenario "OBA-New NonEm" new renewables and new and at-risk nuclear are eligible to receive allocation and other sources are excluded. These variants represent the varying degree of concentration of output-based allocation and the extent and scope to which production incentives can be distributed.

The introduction of production incentives influences the variable cost of electricity generation, and the variation under the policy options can promote the use of one technology at the expense of another. If the favored technology is new investment, the incentives could lead to greater investment in the region. Existing sources may continue to be available even if they do not receive the production incentive.

Figure 2 displays the merit cost ordering for the state of Illinois in the upper Midwest region in the US during the baseload summer block in 2020 in the baseline, before the introduction of the carbon policy. The indicated costs include variable costs plus levelized transmission and distribution costs. At the left of the upward sloping curves are technologies with low variable costs, and the costs increase along the horizontal axis. The other policy displayed on the figure is output based allocation to all covered sources excluding coal (OBA-ExCoal). The production capacity for each technology would change in practice, but we hold the capacity constant at baseline levels in the figure. Further, the variable cost of each plant is affected by the introduction of the carbon price and the availability of a production incentive, but we do not reorder the technologies. The figure shows that coal is negatively affected relative to the baseline, while new nonemitting technologies are favored substantially. New natural gas also benefits. In the operation of the electricity system the ordering of the plants would be revised to show their new variable costs, leading to substantial changes in the operation of the electricity system. The equilibrium outcome is evident in the results reported in Section 4.

Figure 2. Variable Costs including Levelized Transmission and Distribution under the Baseline and Targeted Output Based Allocation Excluding Coal in Illinois (2020)



4. Results

We solve the model over a 22 year horizon from 2013 to 2035, within which 2020 to 2035 is the compliance period for policy scenarios. Here we report results only for 2020, but the results reflect investment and compliance decisions in an inter-annual context. First we examine results in the upper Midwest region and then we report results at the national level.

4.1. Upper Midwest

We find the CPP if implemented through six regional tradable performance standards would reduce electricity emissions in the upper Midwest would be 483 million short tons, a reduction of 11 percent from baseline in that region (Table 2). CO_2 emissions in the upper Midwest are held constant across all the scenarios, but changes in the generation technology that is used in the region leads to changes in emissions of SO_2 and NO_x. These co-pollutants tend to be associated with changes in coal-fired generation in the region. Reduced demand under the Tax scenario coupled with leakage leads to less investment in new gas, which makes room under the cap for more generation from coal. Under output based allocation excluding coal (OBA-ExCoal) the substantial entry of new gas crowds out existing coal. Under output based allocation directed exclusively to new nonemitting sources (OBA-New NonEm) the substantial entry of new wind crowds out new gas generation, making room under the cap for more coal generation. The production incentive is the least, per MWh of production, under the OBA-New NonEm scenario. When coal and gas do not receive a production incentive, they have less incentive to generate electricity reducing the scarcity of emissions allowances. Consequently the allowance price falls resulting in a smaller asset value for distribution to the eligible sources.

Total generation in the region is lowest under the Tax, but under targeted output generation it rises to match or exceed that in the TPS/OBA-All scenario, causing negative leakage. This is evident in the net exports from the region, which also rise to match or exceed that in the TPS/OBA-All scenario.

Because CO_2 emissions in the upper Midwest are constant the change in economic surplus in the region can be meaningfully compared across scenarios. The change in economic surplus is measured as the sum of changes in producer and consumer surplus and government revenue. [19] We report change from baseline because the consumer surplus measure in the baseline is an arbitrary value and depends on the functional form. The change in consumer surplus is least under output based allocation when existing coal is excluded from receiving an allocation. It is greatest under output based allocation directed to new non-emitting resources

[19] Producer surplus is the sum of revenues minus costs, including annualized capital expenditures. Consumer surplus is a partial equilibrium measure that holds the demand function fixed at *Baseline* levels and uses price changes between the *Baseline* and policy scenarios. Quantity changes account for the programmatic energy efficiency expenditures that are proportinal to consumption level across the scenarios. Government revenues include the renewable energy production and investment tax credits.

because the substantial investment in new wind takes advantage of the federal production and investment tax credits, driving up costs for government.

Table 2. Upper Midwest Results for 2020

	BL	*TPS/ OBA-All*	*Tax*	*LDC*	*OBA-ExCoal*	*OBA-New NonEm*
Emissions (M short tons)						
CO_2	540	483	482	Coming	481	479
SO_2	760	606	652		569	647
NO_x	515	454	478		457	481
Electricity Price ($/MWh)	89.9	92.3	98.6		92.5	92.0
Natural Gas Price ($/MMBtu)	4.3	5.3	5.3		5.4	5.1
Allowance Price/Tax ($/ton)	-	15.4	7.7		4.7	1.5
Total Generation (TWh)*	816	820	749		830	816
Coal	471	418	426		396	423
Existing CC Gas	30	32	22		37	20
New CC Gas	8.6	28	0.9		68	0.8
New Wind	18	55	15		42	87
Existing Nuclear	191	191	190		191	190
New Nuclear	0.1	0.1	0.1		0.1	0.1
Net Exports (TWh)	30.9	62.3	16.2		73.6	61.0
Econ Surplus Change from TPS (B$)	-	-0.2	-1.4		-0.1	-1.7
Producer Surplus	-	0.7	0.7		0.3	0.5
Consumer Surplus	-	0.6	-1.9		0.6	0.6
Government Surplus	-	-1.5	-0.2		-1.0	-2.7

*Total includes sources not listed

4.2. Nation

We find the CPP if implemented through six regional tradable performance standards would reduce electricity sector CO_2 emissions in 2020 by 491 million short tons, or 23 percent from the level forecast in the baseline (Table 3). Under the other scenarios emissions in the upper Midwest are held constant under an emissions cap. The introduction of an emissions tax (mimicking a revenue-raising auction) in the region leads to a modest increase in emissions at the national level. This occurs due to electricity transmission from outside the region and greater use of coal at the national level. Importantly, under the tax scenario the increase in CO_2

emissions is accompanied by an increase in emissions of SO_2 and NO_x, which is associated with the greater generation from coal.

The leakage in electricity generation and increase in total emissions observed under the tax scenario is amplified under the cap-and-trade policy when revenues are directed to consumers through the local distribution company in the LDC scenario. In this case equivalent opportunities for leakage exist as under the tax case, but the allocation reduces electricity prices and behavioral responses to the program by providing a subsidy to electricity consumption. Emissions nationally increase from 1,643 in the TPS/OBA-All scenario to 1,657 in the Tax scenario, and they increase further to XXX in the LDC scenario. The emissions change is the result of increased generation outside the upper Midwest, and co-pollutant emissions increase accordingly.

Table 3. National Results for 2020

	BL	*TPS/ OBA-All*	*Tax*	*LDC*	*OBA-ExCoal*	*OBA-New NonEm*
Emissions (M short tons)						
CO_2	2,134	1,643	1,657	Coming	1,633	1,636
SO_2	1,854	1,180	1,206		1,127	1,183
NO_x	1,749	1,189	1,224		1,189	1,214
Electricity Price ($/MWh)	96.3	100	101		100	99.7
Natural Gas Price ($/MMBtu)	4.3	5.3	5.3		5.5	5.2
Total Generation (TWh)*	4,067	3,915	3,870		3,913	3,906
Coal	1,554	1,026	1,035		1,004	1,022
Existing CC Gas	543	616	619		617	600
New CC Gas	415	606	590		634	590
New Wind	81	198	162		189	231
Existing Nuclear	833	836	829		836	829
New Nuclear	44	44	44		44	44
Econ Surplus Change from BL (B$)		-8.3	-8.4		-9.1	-8.6
Producer Surplus		-1.0	-0.1		-1.7	-1.3
Consumer Surplus		-1.1	-3.4		-1.5	0.1
Government Surplus		-6.2	-4.9		-5.9	-7.4

*Total includes sources not listed

The change in emissions is reversed under targeted output based allocation. Allocation on an equal basis per MWh of production to all covered sources (OBA-All) is equivalent to the TPS scenario by construction. Emissions fall if the production incentive is removed from existing coal (OBA-ExCoal) and when all sources except new non-emitting (renewables and nuclear) are excluded (OBA-New NonEm).

Comparison of economic surplus at the national level across scenarios is ambiguous because emissions outcomes are not equal. However, one factor that is noteworthy at the national level is the change in the delivered cost of natural gas price, which reflects changes in the use of gas for electricity generation. The change in the gas price signals changes in economic costs accruing outside the electricity sector but not reported explicitly in our results.

5. Conclusion

The landscape for international climate policy has moved away from a coordinated effort to one in which nations are encouraged to make nationally determined, independent contributions. This change is reflected in the US where climate policy has emerged under the Clean Air Act, which gives states primary responsibility for planning, implementation and enforcement. The Clean Power Plan is at the center of US policy and promises to achieve important emissions reductions. However, the coordination problem among states is substantial. The default policy for states is an emissions rate standard, but states are given the latitude to convert to an emissions mass-based (emissions budget) approach that would directly facilitate cap and trade. The potential interaction among states of rate based intensity standards with mass based emissions caps suggests a possibility for predatory behavior resulting in economic and emissions leakage and an increase in overall emissions.

We use a detailed model of the US electricity system to show that states can design their cap and trade policies to avoid leakage, or even to achieve negative leakage, by targeting the allocation of emissions allowances to provide production incentives. This option allows states to consider policies that can capture the administrative advantages of cap and trade without undermining the overall policy objective. The lessons in the US may reflect back on the international stage, where emissions leakage and policy interactions have been prominent in the policy dialogue.

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