Strategic Policy Choice in State-Level Regulation: The EPA's Clean Power Plan

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Executive Summary

Within the United States, state-by-state variation in regulatory approaches has been more the norm than an exception. Within the utility industries, individual state regulatory commissions have applied substantially different variants of the rate-of-return regulatory framework, while some states have chosen to rely on wholesale power markets instead of vertically integrated utilities. In the environmental realm the Federal Environmental Protection Agency (EPA) has often deferred to state or local air quality regulators to develop specific implementation plans to achieve the EPA's environmental mandates. The Clean Air Act, one of the dominant environmental regulatory instruments, requires the EPA to leave regulatory decisions up to individual states.

Recent actions by the EPA to address greenhouse gas emissions give states significant regulatory discretion. The EPA's "Clean Power Plan" (CPP) proposes major reductions in carbon emissions from electricity generators in the United States (US). By focusing on the electricity sector, the CPP uses existing provisions of the Clean Air Act Amendments to regulate a substantial share of carbon emissions. Due in part to inaction at the federal level, recent US climate policy has been driven almost exclusively by state and regional initiatives. A national framework may decrease inefficiencies created by the patchwork of state and regional policies and could improve US standing in international climate negotiations.

The regulatory approach taken by the EPA is, in many ways, unprecedented. The CPP establishes state-level targets for carbon emissions rates in lbs of carbon dioxide per megawatt

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hour of electricity generated (lbs per MWh). States have a great deal of flexibility in how to achieve these goals. For example, they may adopt the default "rate-based" standard or they could adopt an equivalent "mass-based" regulation such as a carbon cap and trade system. Under a rate-based standard, the state must decrease its carbon emissions rate, whereas under a mass-based standard the state must decrease its aggregate emissions (e.g., create an emissions cap). Because these systems create different incentives, effects on consumers and producers within a state could be quite different depending on the type of regulation adopted both in that particular state as well as in other states because electricity is traded regionally across state lines. Furthermore, the states' private incentives may be at odds with those of a social planner.

In on-going research, we analyze the potential effects of the CPP in terms of electricity market outcomes and state adoption incentives. A complete description of results can be found in the working paper available as Energy Institute at Haas working paper EI-WP-255 or as MIT Center for Energy and Environmental Policy Research working paper WP-2014-09.[1] We briefly summarize the main results and implications for the CPP here. We first analyze a general theoretical model and then calibrate a simulation model to analyze electricity markets in the Western United States. We then use these simulations to investigate likely outcomes under the CPP.

The theoretical model has a market supply curve which is a step function ordering the generation technologies by their marginal cost. This ordering is called the "merit order." Under mass-based carbon regulation, generators must purchase carbon credits to cover all their carbon emissions. This increases each generator's marginal costs in proportion to its carbon emissions and may change the merit order of the generation technologies so that generation is higher from less carbon intensive technologies.[2] Under a tradable rate-based regulation, generators sell or purchase carbon credits based on whether their emissions rate is better or worse than the target emissions rate. This can increase or decrease a generator's marginal costs in proportion to its carbon emissions and may change the merit order.

Our first theoretical result compares the efficiency of the supply, i.e., the merit order, under the different regulatory outcomes and shows increasingly stringent necessary conditions for supply efficiency as regulations depart from the efficient regulation. Under mass-based regulations, supply is efficient if the carbon price in each state is sufficiently close to the social cost of carbon. Supply can also be efficient under rate-based standards since costs increase or decrease in proportion to carbon emissions. However, now the carbon price must equal the social cost of carbon *and* the rate standard must be equal across all the states. Importantly, if carbon prices are equal across states, which would occur if it was possible to trade trade rate-based carbon permits across states, but rate standards are not equal, carbon costs would be different for identical generators in the different states and thus the

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[1] Available at: http://ceepr.mit.edu/working-papers/#2014 and http://ei.haas.berkeley.edu/pdf/working_papers/WP255.pdf.

[2] In practice firms may be allocated free permits implying that some firms may not have to purchase permits to meet their obligations. However, the economic impact of the mass-based standard on a generator's *economic* marginal cost is the same whether they purchase permits or forgo the opportunity to sell permits that they own.

merit order could be inefficient. Put differently, a regime where states have different rate standards will be inefficient even if the states form a coalition that allows for trading of carbon permits.

While an efficient merit order is required to achieve an efficient policy, it is not the only requirement. Even if the merit order of power plants is efficient, if demand is not perfectly inelastic (i.e., if demand responds to price), our work shows that only a mass-based standard can be efficient. This result echoes earlier results in the literature.

Our theoretical model then turns to the incentives for adoption of mass- or rate-based standards from different perspectives. To minimize inefficiencies in the theoretical analyses, we assume that carbon prices equal the social cost of carbon. We first examine the incentives of a coalition of states and then the incentives of a single state. For the coalition of states, adoption of mass-based standards is best from an efficiency perspective. However, from the perspective of an individual state, adoption of a rate-based standard (instead of a mass-based standard) results in lower electricity prices. This benefits consumers (both in this state and in other states) so consumers have an incentive to lobby for adoption of rate-based standards.

From a generator's perspective, the lower electricity prices from adoption of a rate-based standard could lead to lower profits. However, regulated generators' costs fall by more than the electricity prices fall. This leads to a split in incentives for generators. Generators whose operations are not covered by the regulation, e.g., distributed generation, renewables, nuclear, small fossil plants, prefer the high electricity prices associated with mass-based standards. On the other hand, regulated generators (e.g., existing fossil plants) benefit from lower costs and prefer rate-based regulation. Holding carbon prices fixed we show that adoption of a rate-based standard is a "dominant strategy" from the perspective of "covered" generators, but adoption of a mass-based standard is a dominant strategy from the perspective of "uncovered" generators.

Although consumers and covered generators prefer rate-based standards, mass-based standards result in carbon-market value which could be used to compensate consumers and covered generators for their losses under mass-based standards through auctioning off of permits. This compensation could occur, for example, through the allocation of the carbon permits. However, theory cannot provide clear guidance on whether or not carbon market revenues would be sufficient to compensate consumer and covered generators. Thus, whether or not potential compensation is possible is an empirical question.

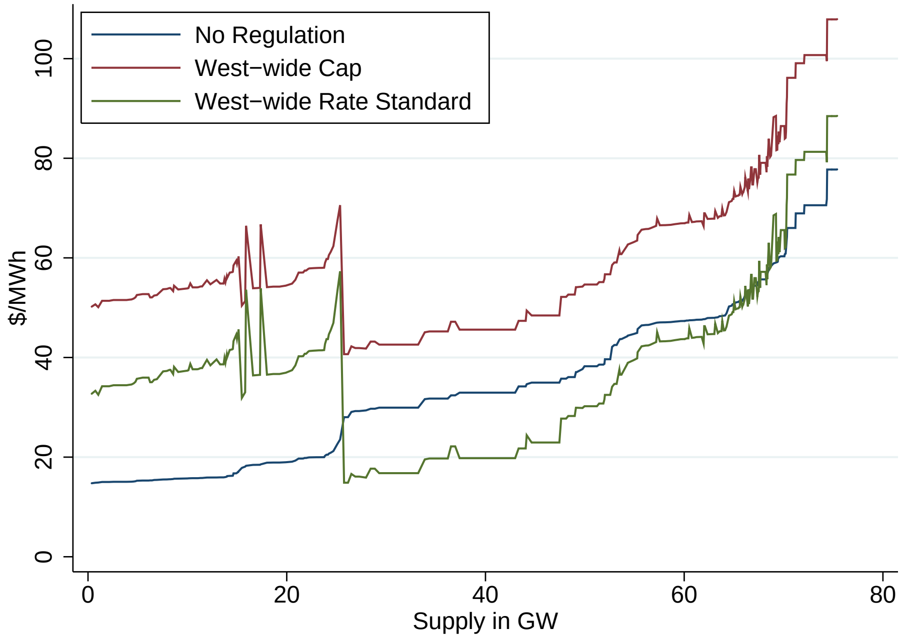
We next calibrate the model for the eleven states which make up the western interconnection of the U.S. electricity grid. There are two main differences between our theoretical model and our simulation model. First, the simulation model recognizes that electricity cannot flow freely throughout the West. Thus our simulation model has four demand regions with potentially different electricity prices in each region and limited transmission capacity between regions.

Second, our simulation model does not hold carbon prices fixed, but rather tries to imitate the regulations (i.e., the caps and rate standards) which would result under the CPP. In particular, the simulations attempt to implement the reductions in the emissions rates required from redispatch of existing generation resources under the second building block of the CPP. These emissions reductions range from 0% in Montana and Idaho to 40% in Arizona. Thus we model significant heterogeneity in the regulations.

The model calibration is based on 2007 supply and demand conditions. We update the model with current natural gas prices and test the sensitivity of our results to this assumption. The model simulates a variety of regulation scenarios including: no regulation (business as usual), a single west-wide mass-based standard, a single west-wide rate-based standard, state-by-state mass-based standards, and state-by-state rate-based standards. We also simulate mixed mass- and rate-based regulations across two coalitions: the Coastal states (CA, OR, and WA) and the Inland states (AZ, CO, ID, MT, NM, NV, UT, and WY).

We first illustrate the effects of the different regulations on the market supply curve (the merit order) for electricity. In Figure 1 we compare the business as usual supply curve to the full marginal costs under both mass- and rate-based standards. Compared to the business as usual supply curve, a west-wide mass-based standard increases the full marginal costs for all generators in proportion to their carbon emissions. A west-wide rate-based standard raises the full marginal costs of coal-fired generation, but *lowers* the full marginal costs of most gas-fired generation. The full marginal costs from a west-wide mass- or rate-based standard are remarkably similar across units (the relative prices are correct) but the full marginal costs under a rate-based standard are lower.

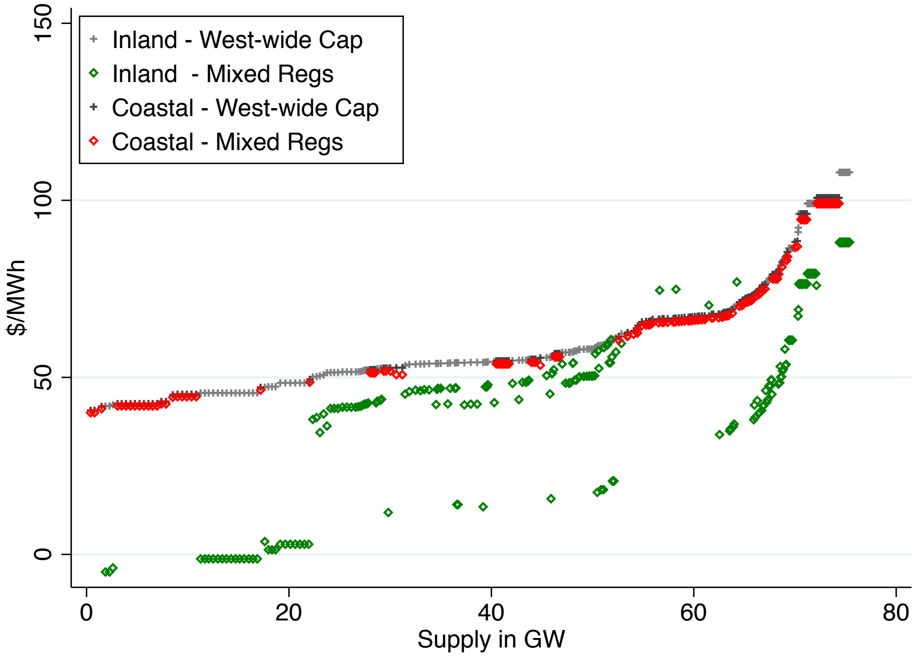
Figure 1: Merit order under different regulations: BAU and west-wide mass- and rate-based standards.



Note: Generating units sorted on x-axis by marginal costs under BAU (Scenario 0).

When states fail to coordinate on a policy, the merit order can be "scrambled" quite dramatically. In particular, state-by-state mass- or rate-based standards result in full-marginal costs (and a merit order) which are substantially different than would result under a west-wide policy. Figure 2 illustrates the scrambling of the merit order when the Coastal states adopt a mass-based standard and Inland states adopt a rate based standard.

Figure 2: Merit order under different regulations: west-wide mass-based standards and mixed regulation.



Note: Generating units sorted on x-axis by full-marginal costs under west-wide mass-based standards (Scenario 1). Mixed regulation has Coastal mass-based standard and Inland rate-based standard.

To estimate the welfare effects of the different policies, we first calculate the short-run equilibria under the different scenarios. Based on the equilibrium electricity prices we can analyze the changes in consumer surplus, generator profits, and carbon market revenue. In addition, we can calculate the deadweight loss of each scenario based on an estimate of the social cost of carbon. The results of our short-run analysis are shown in Table 1.

Our short-run analysis shows substantial deadweight loss from a failure to coordinate policies. In particular, state-by-state rate standards result in a deadweight loss which is twice that of business as usual, i.e., which is twice as bad as doing nothing. In contrast, the deadweight loss from failures to coordinate on mass-based standards is only 30% of the BAU deadweight loss.

Table 1: Equilibrium outcomes for business as usual and eight policy scenarios.

	0 No Reg	1 CAT	2 CATs	3 Rate	4 Rates	5 CAT Rate	6 CAT Rates	7 Rate CAT	8 Rates CAT
Electricity Price ($/MWh)	$ 40.38	$ 59.80	$ 68.17	$ 41.02	$ 84.68	$ 53.65	$ 72.78	$ 61.38	$ 74.96
Electricity Quantity (GWh)	411,362	-13,133	-18,863	-405	-30,050	-9,141	-22,304	-14,283	-23,310
Emissions (MMT)	313.81	-52.45	-52.45	-52.70	-75.16	-49.04	-69.70	-54.07	-59.79
CAT Permit Price ($/MT)		$ 35.10	$ 44.36			$ 33.23	$ 63.48	$ 30.19	$ 41.30
Rate Permit Price ($/MT)				$ 47.91	$ 287.64	$ 89.40	$ 187.48	$ 190.91	$ 331.18
Consumer Surplus ($ bn.)	$ 417.36	-$14.14	-$20.36	-$0.33	-$33.09	-$10.00	-$24.06	-$15.70	-$25.66
Covered Generator Profit ($ bn.)	$ 6.47	-$2.48	-$0.72	-$1.10	+$14.48	+$2.24	+$7.04	+$0.85	+$3.57
Uncovered Generator Profit ($ bn.)	$ 13.48	+$6.36	+$9.21	+$0.14	+$15.06	+$4.55	+$10.97	+$7.09	+$11.61
Transmission Profit ($ bn.)	$ 0.14	-$0.07	-$0.01	-$0.06	+$0.36	+$0.04	+$0.10	+$0.10	+$0.18
Production Costs ($ bn.)	$ 12.69	+$1.19	+$0.91	+$2.42	+$2.42	+$1.80	+$2.45	+$1.39	+$0.99
Carbon Market Rev. ($ bn.)		+$9.17	+$10.54			+$1.78	+$3.40	+$6.27	+$8.58
Abatement Cost ($ bn.)		-$1.15	-$1.33	-$1.34	-$3.19	-$1.39	-$2.53	-$1.39	-$1.72
Avg. Abatement Cost ($/MT)		+$21.95	+$25.41	+$25.46	+$42.46	+$28.25	+$36.34	+$25.72	+$28.74
Δ Carbon Damages ($ bn.)		-$1.84	-$1.84	-$1.85	-$2.64	-$1.72	-$2.45	-$1.90	-$2.10
Deadweight Loss ($ bn.)	-$0.69	+$0.00	-$0.18	-$0.18	-$1.24	-$0.35	-$0.78	-$0.18	-$0.31

Notes: Results from Scenarios 1-8 are reported as changes relative to Scenario 0. "+" indicates an increase and "-" indicates a decrease. "Abatement Cost" is the sum of consumer surplus, profits (covered, uncovered, and transmission), and carbon market revenue. Carbon damages assume a social cost of carbon equal to $35.10.

The deadweight loss from adopting a west-wide rate-based standard is about 30% of the BAU deadweight loss. This DWL results from electricity prices that are too low relative to the first best and hence too much consumption of electricity. This lower electricity price implies higher consumer surplus under a rate-based standard. Our calculations show that carbon market revenues (e.g., from auctioning carbon permits) could only partially compensate consumers even if they received all the carbon market revenue from a mass-based standard.

The lower electricity prices under a west-wide rate-based standard have different effects on generator profits depending on whether the generators are covered by the Clean Power Plan (e.g., most fossil-fired plants) or are not covered (e.g. renewables, nuclear, and distributed generation). Under rate-based standard, covered generator profits are higher (by about $1 billion per year) but uncovered generator profits are lower (by about $6 billion per year) relative to a mass-based standard.

Our simulations suggest that efficiency is enhanced when states form regional trading markets. A natural question, then, is whether states will have the incentive to form such coalitions? We consider the incentives of the two blocks of states defined above: coastal and inland states. Our calculations show that from an abatement cost perspective (the sum of consumer surplus, generator surplus, and any carbon market revenue) the strategic interaction between the regions would result in west-wide adoption of a mass-based standard, i.e., Cap/Cap is the "Nash equilibrium".

Table 2: Consumer surplus incentives in the coastal and inland west.

		Inland	
		Cap	Rate
Coastal	Cap	- $8.38 , - $5.75	- $6.15 , - $3.84
	Rate	- $9.74 , - $5.96	- $0.00 , - $0.32

Notes: Consumer surplus is measured relative to business as usual (Scenario 0) in $ billion. "+" indicates an increase and "-" indicates a decrease.

When we look at the individual sets of stakeholders, Cap/Cap is no longer an equilibrium. From a consumer's perspective the Nash equilibrium would be Rate/Rate, i.e., would result in west-wide adoption of a rate-based standard. The normal form from the consumer's perspective is shown in Table 2. The incentives of firms depend on the mix of covered and uncovered generators. From the generator's perspective we find that there is a strong incentive to have different regulatory mechanisms; Cap/Rate and Rate/Cap are both Nash equilibria. The normal form from the generators' perspective is shown in Table 3.

Another important dimension over which states and EPA will need to evaluate their compliance plans is the treatment of newly constructed fossil-fired power plants. Technically, Section 111d of the Clean Air Act covers only existing sources. New sources are covered under a different Section and will have to comply with a source-specific CO_2 emissions rate

Table 3: Profit incentives for all generation (covered and uncovered) in the coastal and inland west.

		Inland	
		Cap	Rate
Coastal	Cap	+ $4.88 , - $1.00	+ $3.18 , + $3.61
	Rate	+ $7.71 , + $0.23	+ $1.12 , - $2.08

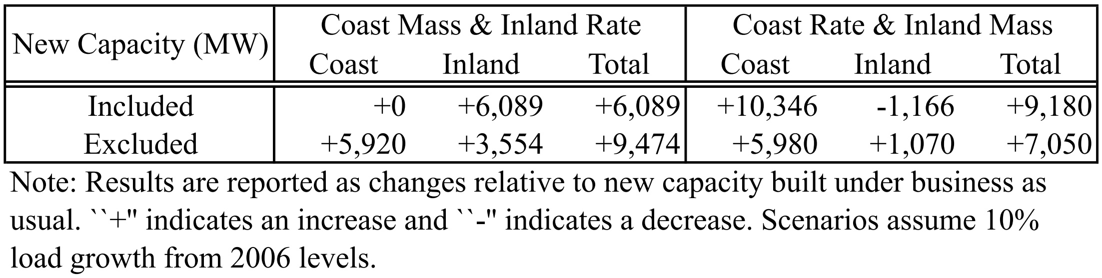
Notes: Profit is measured relative to business as usual (Scenario 0) in $ billion. "+" indicates an increase and "-" indicates a decrease.

standard. At the time of this writing, the extent to which state-level plans may or may not include new plants under their Clean Power Plan compliance strategies has not been resolved.

We analyze investment in new combined cycle gas turbines over the medium-term under an assumption of 10% demand growth relative to 2007. Our calculations show that average abatement costs are lowest when new investment is included under a mass-based standard and highest when it is excluded under a mass-based based standard. Our calculations show that average abatement costs are lower when new investment is included than when it is excluded.

The location of new investment will also depend on the regulatory mix. In general, new investment will occur in the rate-based regions if it is included under the CPP. Our calculations show that investment swings can be quite dramatic for different changes in the regulatory mix. When new plants are included in CPP compliance new generation shifts out of mass-based regions toward rate-based regions. This is shown in Table 4 for our medium-term scenario. If new generation is excluded from the CPP, capacity growth occurs in both regions, though weighted more heavily toward the coast.

Table 4: New capacity under mixed regulation when new NGCC investment is included and *not* included under the CPP.



New Capacity (MW)	Coast Mass & Inland Rate			Coast Rate & Inland Mass		
	Coast	Inland	Total	Coast	Inland	Total
Included	+0	+6,089	+6,089	+10,346	-1,166	+9,180
Excluded	+5,920	+3,554	+9,474	+5,980	+1,070	+7,050

Note: Results are reported as changes relative to new capacity built under business as usual. ``+" indicates an increase and ``-" indicates a decrease. Scenarios assume 10% load growth from 2006 levels.

Overall, our findings indicate that despite the *opportunities* the CPP provides for states to coordinate and implement compliance plans that can efficiently achieve their joint targets, the incentives of individual states to participate in those plans are conflicted. Indeed, there can easily be circumstances when states find it in their own interest to adopt a regulatory approach that is contrary to those of its neighbors. Unfortunately, when incentives do not favor coordination, this may lead to adoption of less efficient mixed policies.