HOW GOOD IS GOOD? OPTIMAL PERFORMANCED-BASED STANDARD UNDER THE US CLEAN POWER PLAN~~*PURE OR HYBRID?: POLICY OPTIONS FOR RENEWABLE ENERGY*~~

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Overview

Kommentiert [t1]: Do we consider oligopoly in power sector in table 1? If so, we may mention this somewhere? But it is not essential for this abstract.

Clean Power Plan (CPP) is introduced by the US Environmental Protection Agency to cut CO2 emissions from existing fossil-fuel power plants by 30% below 2005 levels by 2030. While the proposal establishes a state-specic target with various building blocks that lay out possible reduction strategies, it leaves states and the power sector with considerable flexibility in attaining their targets. More specifically, a state can decide to adopt either 1) a default performance-based standard under which tons of CO2 emissions per MWh of electricity generated serve~~r~~s as binding regulatory constraint, or 2) an equivalent mass-based standard, such as in a traditional Cap-and-trade (C&T) regime adjusted by GDP growth projections. Furthermore, those states could form an alliance that allows them to trade either under a "mass-based" or a "performance-based" standard. This paper analyzes the efficiency of the CPP policy when the government can optimally determine the state-specific performance standard by maximizing social surplus. We then compare the policy to other forms of policies, e.g., a single aggregate cap, traditional C&T, when all cases subject the region to a fixed emission.

Approach

We ~~rely~~ focus on a simple three-region system with ten generating plants owned by three firms and consider a total of five scenarios. Those five scenarios will be subject to the same total emissions so that we can bypass the discussion on damage costs. Scenario (a) is our baseline where each region is subject to its own individual (different) performance standard. Firms who own facilities can sell power to other locations. In scenario (b), each region is subject to an equal performance standard while the total emission is fixed at the level of the scenario (a). (In solving the model, we iterate the performance rate until the total emission in the (b) equal to (a).) We allow "explicit" permit trading in scenario (c) by formulating the cap as a single cap constraint. Scenario (d) is formulated as a bi-level problem where the government is the upper level decision maker who can optimally decide individual performance rate subject to the lower level problems of producers and the grid operator as well as the total emission. Finally, the scenario (e) is a traditional C&T policy with three regions ~~are~~ subjecting to an aggregate cap.

Table 1: Simulation outcomes under various scenarios

	(a)			(b)			(c)			(d)			(e)		
Weighted price [$/MWh]	82.9			74.9			74.9			77.0			84.7		
Total CO2 [tons]	589.4			589.4			589.4			589.4			589.4		
Consumer Surplus [$]	59,856.4			72,859.0			72,859.0			72,872.4			63,449.5		
Producer Surplus [$]	69,820.0			59,747.2			59,747.2			60,192.1			70,314.5		
Social Surplus [$]	129,676.4			132,606.1			132,606.1			133,064.5			133,764.1		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Price [$/MWh]	102.6	34.5	91.1	81.9	44.8	99.6	81.9	44.8	99.6	78.7	58.3	95.7	90.7	56.7	90.0
Demand [MW]	770.2	340.0	154.6	897.3	280.0	90.0	897.3	280.0	90.0	916.6	201.8	119.8	842.8	211.3	162.6
CO2 price [$/ton]	291.8	142.5	291.8	254.8	254.8	254.8		254.8		262.0	262.0	262.0		75.7	

Results and Discussions

Table 1 reports results of our five scenarios, each column corresponding to one scenario. The table contains two panels with the top panel giving the market outcomes, the weighted price, the CO_2 emissions and the social surplus measurements. The lower panel reports the price and the demand by three regions, as well as the CO_2 price. In scenario (a), the baseline performance standard for three regions is 0.4, 0.5 and 0.5 t/MWh, respectively. The total emission produced by the scenario (a) is then used in other four scenarios. The performance standard that leads to the equivalent total emission is 0.47 t/MWh for both scenarios (b) and (c). The optimal policy scenario (d) is 0.48, 0.35 and 0.63 t/MWh for the regions 1-3, respectively.

Several observations emerge from the table. F~~r~~irst, even allowing for "implicit" permit trading, the permit prices among three regions could be diverged (Scenario (a)): 291.8 $/t for regions 1 and 3, and 142.5 $/t for region 2. As the market allows producers to decide where to sell to, and consumers (an LSE for example) choose from whom~~ere~~ to buy power ~~from~~ in order to satisfy respective performance standard, this divergence of the permit prices implies that the market exhausts all options to equating the permit prices. This also suggests that a sing~~el~~e aggregated performance standard that allows for "explicit" trading of permits will enhance social surplus through equating the marginal abatement cost or permit prices (Scenario (c)). In fact, the social surplus increases by $2,920 or 2.3% when comparing (c) to (a). Second, scenarios (b) and (c), which impose the same performance standard, produce the same market outcomes, with the same permit and power prices, and the distribution of economic rent. However, even with the same performance standard (0.47 t/MWh), there is no guaran~~et~~tee that the two scenarios should result in the same market outcomes as mathematical formulation of the two scenarios is~~are~~ different. Third, under the scenario (d) with the optimized policy, the social surplus increases by $460 or 0.3% of that in (b) or (c). Fourth, the cross-subsidy of the performance-based polices (scenarios (a)-(d)) effectively subsiding lower ~~emission~~ emission~~-~~/higher cost power that determines the power prices, ~~by~~ thereby inflating the demand due to lower power prices. The inflated demand also increases demand of tradable permits and drives up the permit prices. In general, higher power prices accompanied with a lower permit price are observed in the scenario (e) when comparing to other scenarios. Finally, we argue that mass-based policy remains to be more efficient. In fact, while the government collects all the proceedings from auctioning of mass-based tradable permits, the tradable performance-based standard is inherently revenue neutral since it involves transfers of economic rent from high-emitting to low-emitting units. Therefore, if we assume the permits will be grandfathered to producers so the proceedings will go to producers, the producers suplus in the scenario (e) will increase to $108,071 accounting for the economic rent of the permit proceedings of $44,621 ($75.7/t×589.4 t). Overall, the social surplus under the ~~a~~ mass-based policy (e) will be $700 higher than the optimal policy scenario (d) under a performance-based standard or by a margin of 0.52%.

Concluding Remarks

Overall, our findings indicate that efficiency is most likely to be achieved under a mass-based policy, while performance-based approaches may be less efficient when policies are subject to the same level of the total emissions. With the performance-based policies, it is likely that cross-subsidy effect represents a sizable wealth transfer from low-cost-high-emitting units to high-cost-low-emitting units, and to consumers due to the lower power prices. Even if the government is allowed to optimally design the performance standard as in the scenario (~~e~~d) that can fully anticipate responses from the producers and the gird operator, the resulting social surplus remains to be less than of the mass-based policy. This suggests that if, based on scientific ground, ~~by~~ capping the power's sector emission at certain level will prevent catastrophic outcomes, a mass-based policy, which does not require optimal policy design as the optimal performance standard, will be a better policy to implement.