WORKING PAPER
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Carbon Standards Re-Examined

An Analysis of Potential Emissions Outcomes for the Affordable Clean Energy Rule and the Clean Power Plan

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I. The Context

On June 19, 2019, the U.S. Environmental Protection Agency (EPA) repealed the 2015 Clean Power Plan (CPP) and released the final Affordable Clean Energy rule (ACE rule). As part of their final rule package, EPA also released the Regulatory Impact Analysis (RIA) which estimates expected changes in emissions of carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) between 2021 and 2050 for a reference case with no carbon standards, the CPP, and the ACE rule.

The final ACE rule is a limited "source-based" regulation that defines the "Best System of Emission Reduction" (BSER) as heat rate improvements (HRI) at individual coal-fired electricity generating units[1]. By contrast, the CPP is a "system-based" approach that defines the BSER based on how the electrical grid of interconnected generating facilities functions and the types of measures that have reduced emissions in the past; including renewable energy generation, fuel-switching, co-firing, demand-side energy efficiency, and emissions trading.

Our team previously analyzed EPA's 2018 draft ACE rule and RIA and published a peer-reviewed paper[2] showing that, by EPA's estimates, the draft rule could result in emissions rebound at the national, state, and facility levels with increases in emissions in up to 20 states and DC, and higher national CO_2 emissions in 2050 compared to no carbon standards. "Emissions rebound" occurs when a facility undergoes heat rate improvements to increase its efficiency and as a result operates longer and more often, leading to increased emissions[3]. The results of this previous paper were summarized in the fact sheet, *Carbon Standards Examined*.

For the current analysis, we examined the underlying assumptions, emissions results, and conclusions in the 2019 final RIA for the ACE rule and compared them to the 2018 draft RIA. We also modeled the ACE rule and the CPP under an alternative reference case. Considerable uncertainty exists in any assumptions about "business as usual" and future policy scenarios as the COVID19 pandemic has laid bare. These assumptions drive estimated emissions changes and climate and health outcomes. This uncertainty is particularly pronounced in highly dynamic systems, such as energy systems, that experience large fluctuations in response to unpredictable markets and evolving technology.

Our results shed new light on the potential magnitude of emissions rebound under the ACE rule, the emissions reductions that could occur under an updated version of the CPP, and the robustness of these two policy approaches under an alternative reference case with higher electricity demand, natural gas prices, and renewable energy costs than those assumed in the 2019 final ACE rule RIA.

II. The Bottom Line

The final 2019 RIA for the ACE rule estimates that establishing HRI as the BSER would result in a 0.7% decrease in national CO_2 emissions from the electricity generation sector in 2030 and increases in CO_2 emissions at roughly one-fifth of the regulated facilities. Our supplemental analysis shows that:

1. The ACE rule is likely to result in even higher national carbon dioxide emissions in 2050 and more harm to public health and ecosystems than EPA estimated in the final 2019 Regulatory Impact Assessment.
2. The Clean Power Plan, if updated to reflect recent emissions reductions, would achieve much larger emissions reductions than EPA estimated in its repeal.
3. Emissions reductions under the updated Clean Power Plan would be robust under shifting market conditions while emissions under the ACE rule are likely to increase further.

Our analysis shows that the final ACE rule would do little to address climate change and would likely have even greater adverse air quality and health effects in some states than EPA has projected, consistent with past research[4]. They also show that the large CO_2 emission reductions that would be achieved with an updated version of the CPP would be robust under higher costs and electricity demand while emissions under the ACE rule would likely increase. Both the magnitude and the durability of emissions reductions to market fluctuations will influence future climate change, air quality, and human and ecosystem health.

III. The RIA Underestimates the Potential Magnitude of Emissions Rebound Under the ACE Rule

With updated assumptions in the final RIA, EPA estimates that the final ACE rule would achieve an average heat rate improvement of 1.2%, resulting in a 0.7% reduction in electricity sector emissions of CO_2 compared to the no-policy reference case in 2030. This change in CO_2 represents approximately a 35% reduction from 2005 levels, almost all of which is due to anticipated continued declines in emissions under the no-policy reference case. EPA further estimates that in 2045, national emissions of CO_2 could be slightly higher under the ACE rule compared to no regulation.

At the state level, EPA estimates that under the final ACE rule emissions of CO_2 would increase in 15 states plus DC compared to their no-policy reference case (Table 1, Case 1), representing an increase in emissions at 18% of regulated facilities in 2030. EPA further estimates that emissions of SO_2 would increase in 14 states and emissions of NO_x would increase in 13 states plus DC in 2030 compared to no policy. SO_2 and NO_x can adversely affect air quality by contributing to the formation of fine particulate matter ($PM_{2.5}$) and ozone. Based on our side-by-side comparison of several ACE policy cases, we conclude that the final RIA for the ACE rule underestimates the potential magnitude of emissions rebound for CO_2, SO_2, and NO_x.

The final 2019 RIA includes several notable assumptions about both the no-policy reference case and the ACE policy case that influence the emissions and health outcomes. The final RIA did not consider EPA's plan to change the New Source Review (NSR) provision of the Clean Air Act that had been a central element of the draft RIA. However, EPA has announced that it intends to finalize NSR changes to reduce the likelihood that regulatory review would be triggered when facilities undergo physical or operational changes that may lead to increased emissions. The final RIA notes that the impact of NSR reform on the projected outcomes of the ACE rule will be analyzed at that time.

In addition, the ACE policy case in the final RIA analysis excluded two candidate HRI technologies (blade path upgrades and redesign/replace economizers) that are part of the BSER because it is assumed that they could trigger NSR. These two technologies have the greatest potential to improve heat rates of the six candidate technologies included in the final RIA and may become cost-effective when EPA modifies NSR. Biomass co-firing was also eliminated from the final ACE rule and not considered in the modeling of emissions impacts. Biomass has relatively high emissions factors at the source therefore emissions impacts should be evaluated if it is reinstated in the ACE rule. Notably, the reliance in the ACE rule on the criterion of "broadly achievable across the country" to determine eligible practices and technologies for the BSER runs counter to the wide variation in facility types in the U.S. and rules out several widely available options for reducing CO_2 emissions, resulting in a low performance standard for emissions reductions.

The final ACE RIA also excludes the Section 45Q tax credit for carbon capture in the analysis. The Section 45Q amendment to the Internal Revenue Code was included in the Bipartisan Budget Act of 2018 and provides a tax credit for carbon capture, utilization, and storage (CCUS) to incent investment in CCUS technology at electricity generating plants and industrial facilities. While the RIA provides an alternative no-policy reference case with the Section 45Q tax credit, it is not included in the RIA ACE policy case. While ACE would not be binding for fossil-fuel-fired plants that are built or retrofitted with CCUS given their low carbon emissions, we anticipate that the fact that ACE is likely to extend life-time of fossil fuel plants would make the use of the tax credit and the build-out of fossil fuel plants with CCUS feasible for more plants than without ACE. Therefore, it is important to consider the potential co-pollutant effects of the ACE rule with the availability of 45Q tax credits. We modeled a reference case and an ACE policy case with 45Q to enable a more comprehensive comparison (Table 1, Case 4).

The overall effect of assumptions about NSR, HRI technologies, and the 45Q tax credit for CCUS in the final ACE rule RIA is to (1) reduce the number of candidate coal plants that would implement heat rate improvements compared to their draft RIA; (2) decrease the fleetwide heat rate improvement that is achieved by affected sources from 4.5% to 1.2%; and (3) overlook the potential for the implementation of the ACE rule and the 45Q tax credits to result in higher co-pollutant emissions. As a result, the assumptions in used by EPA in the 2019 ACE RIA minimize the estimated magnitude of potential emissions rebound at regulated and non-regulated facilities.

We conducted a side-by-side comparison of four different ACE policy cases to evaluate the potential for emissions rebound under alternative assumptions that bracket a range of options for how the ACE rule may actually be implemented given the anticipated NSR reform and implementation of 45Q (Table 1). Cases 1-3 are taken from EPA's 2018 and 2019 RIAs. Case 4 was independently modeled with the same Integrated Planning Model (IPM) that EPA used in this and other RIAs. The four cases suggest that (1) state-level SO_2 emissions rebound could be higher with an increase in HRI(Case 2 compared to Case 1); (2) state-level emissions rebound for all three pollutants could be higher with a HRI of 4.5% facilitated by the addition of technologies that would be supported with NSR reform than with a HRI of 2% (Case 3 compared to Case 2); and (3) state-level emissions rebound for all three pollutants could be higher for a given heat rate improvement when 45Q is included due to the combination of extending the life of fossil-fuel-fired plants under ACE and incenting CCUS (Case 4 compared to Case 3). Case 4 underscores that the 45Q tax credit could exacerbate co-pollutant emissions rebound due to the substantial heat rate penalty that can be incurred by CCUS[5].

Table 1: Estimated Emissions Increases for States with Emissions Rebound Under Four HRI Policy Cases± in 2030
(million short tons CO_2, thousand short tons SO_2 and NO_x)

	ACE Case 1: EPA 2019 FINAL ACE RIA[6] 1.2%* HRI @ $29/kW			ACE Case 2: EPA 2018 DRAFT ACE RIA[7] 2% HRI @ $50/kW			ACE Case 3: EPA 2018 DRAFT ACE RIA[7] 4.5% HRI @ $50/kW			ACE Case 4: Our 2019 Case 4.5% HRI @ $50/kW with 45Q		
	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
# of states/DC	15+ DC	13	13+DC	16 + DC	12	13	18 + DC	19	20+DC	14	15	20
Total rebound (MST for CO_2, TST for SO_2 and NO_x)	2.9	2.4	2.1	2.1	4.8	1.0	8.5	12.0	4.3	19.0	38.0	15.0
Min/Max state increase	<0.01 - 0.82	0.02 - 0.54	0.01 - 0.55	<0.01 - 0.60	0.01 - 0.90	0.01 - 0.49	<0.01 - 1.4	<0.01 - 2.4	<0.01 - 0.90	<0.01 - 4.32	0.03 - 11.5	<0.01 - 3.76

±Results represent the difference between the policy case and its associated mid-range, no-policy reference case. Emissions from generation on tribal lands included. *Equivalent to a 1.5% average capacity weighted HRI for the subset of sources that implement HRIs.

Given the results in Table 1, we expect that the magnitude of state-level emissions rebound from the ACE rule, and the resulting local air quality and health impacts, are likely to be larger than estimated by EPA in the final

2019 ACE RIA. This finding is consistent with our previous analysis in suggesting that NSR reform is likely to lead to higher HRI, and higher HRIs can have worse emissions outcomes than lower HRIs[4].

IV. A Clean Power Plan Would Likely Achieve Larger Emissions Reductions Than Estimated by EPA

EPA repealed the CPP in June 2019, emphasizing the Agency's assessment that the CO_2 emissions outcomes of a 32% reduction from 2005 by 2030 would be achieved without its implementation. However, it is possible that the current, or an updated, version of the CPP would achieve additional emissions reductions either directly, by establishing a regulatory approach that controls leakage and allows for ratcheting down emissions over time; or indirectly, by sending a clear market signal that the standards will ensure a durable transition away from fossil fuel to cleaner energy sources.

The 2019 RIA concludes that the CPP will have no impact on CO_2 emissions compared to no policy, based on a set of modeling assumptions that depart from the original expectations for the implementation of the CPP. Specifically, the CPP scenario in the final RIA analysis does not require states to limit emissions leakage to mitigate the potential effects from new sources and interstate trading, nor does it account for the use of demand-side energy efficiency for compliance. The final RIA analysis also delays the implementation of the CPP until 2025 (referred to as tolling). The net effect of these modified assumptions is to depress the potential emissions benefits of the 2015 CPP.

In recognition of the inter-connectedness of the energy system and full range of measures that have been effective at reducing emissions, we modeled an updated version of the CPP to reflect what the CPP might achieve if it were established in 2019. Specifically, the mass-based caps have been updated to reflect more current natural gas prices and renewable energy availability as well as the emissions progress that has been made since 2015. This resulting 'Updated 2019 CPP' case lowers the 2015 mass-based emissions caps by half, applies the standards to all existing fossil-fuel-fired facilities, controls the potential for leakage by constraining the emission rate from new natural gas builds to 100 pounds per megawatt-hour, allows national trading, and assumes a 1.5% incremental annual increase in demand-side energy efficiency. The results show that the 'Updated 2019 CPP' could achieve an estimated 60% reduction in CO_2 emissions from 2005 levels by 2030, which is equivalent to a 37% reduction from the no-policy case (Table 2).

Under the 'Updated 2019 CPP', total national emissions of SO_2 and NO_x are estimated to decline by 47% and 40%, respectively, from the no-policy case in 2030 (Table 2). Further, large SO_2 and NO_x emissions reductions are projected for several states with high air pollution burdens including Ohio, Illinois, Pennsylvania, Florida, and Texas, which would result in air quality improvements and health benefits.

Table 2: Change in Electricity Sector Emissions for Policy Cases Compared to No-Policy Reference Cases* in 2030

Policy Case	CO_2	SO_2	NO_x
ACE rule (EPA 2019 model run)	-0.7%	-0.6%	-0.9%
2015 CPP (limited trading, EPA 2018 model run)	-3.5%	-3.6%	-6%
Updated 2019 CPP (new model run)	-37%	-47%	-40%

*The no-policy reference cases represent mid-range reference case conditions.

V. CO_2 Emissions Outcomes Would be Robust Under a Clean Power Plan and Not Under an ACE Rule

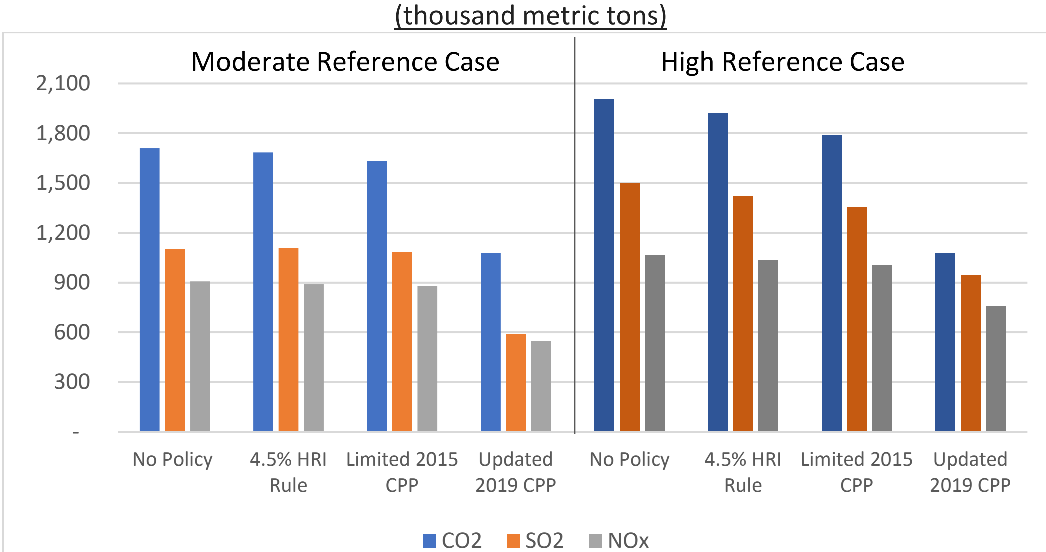
Given that energy markets are changing rapidly, and the future is extremely difficult to predict, it is useful to evaluate carbon standards under a range of plausible future energy scenarios, or reference cases. The draft and final RIAs evaluated the emissions consequences of ACE and the EPA's interpretation of the CPP under reference cases that represent mid-range assumptions for electricity demand, alternative energy costs, and other assumptions. We conducted new model calculations to assess the extent to which the estimated emissions outcomes from the ACE rule and the CPP would be robust under changing external conditions.

In this analysis, our 'Moderate Reference Case' uses similar demand, natural gas, and renewable energy costs as the draft ACE RIA. Our 'High Reference Case' uses higher energy demand, natural gas prices, and renewable energy costs. The assumptions for the 'High Reference Case' are based on the Annual Energy Outlook (AEO) 2018[8] high demand case; AEO2018 low oil and gas resource case (i.e., high gas price); AEO2018 energy storage costs; and the 2018 Annual Technology Baseline[9] high scenario for wind and solar costs from the National Renewable Energy Laboratory. Both of our reference cases include the 45Q tax credit for CCUS. The 45Q tax credit has the effect of lowering the total reference case emissions of CO_2.

For the ACE policy case in this comparison, we assumed a 4.5% average fleetwide HRI at $50/kW for regulated coal-fired utilities. We used two CPP policy cases in the analysis. The 'Limited 2015 CPP' case represents one example of an unlikely worst-case scenario that applies the 2015 emissions targets to existing coal-fired and natural gas-fired facilities with state trading but does not constrain emissions from new natural gas plants that are projected to be built. This approach is similar to how the CPP was modeled in the final ACE RIA and departs from how the CPP was intended to be implemented. The 'Updated 2019 CPP' is described in section IV above.

Our modeling results show that all estimated emissions are higher under the 'High Reference Case' compared to the 'Moderate Reference Case', except for CO_2 emissions in the 'Updated 2019 CPP' (Figure 1). Estimated CO_2 emissions for the ACE '4.5% HRI Rule' increase 14% under the 'High Reference Case' compared to the 'Moderate Reference Case' due to a decrease in natural gas and increase in coal-fired generation. The emissions increases for the 'Limited 2015 CPP' demonstrate the role of controls on emissions leakage in securing emissions reductions under shifting baselines. The CO_2 emissions under the 'Updated 2019 CPP' remain unchanged between the two reference cases due to the existence of stringent mass-based emissions caps for all existing sources, rate-based controls on emissions leakage from new builds, and constraints that limit trading to within states.

Figure 1: Estimated Electricity Sector Emissions Under a Moderate and High Reference Case in 2030 (thousand metric tons)



Notably, our modeling results also show that the implementation of the 45Q tax credit in the 'High Reference Case' induces an increase in coal-fired electricity generation with carbon capture. As a result, the emissions of co-pollutants increase, and are higher relative to CO_2 emissions, under the 'Moderate Reference Case' due to the heat rate penalty that carbon capture technology can incur[5].

These results underscore the need to evaluate policy outcomes under a range of reference cases as well as the importance of explicitly modeling the cumulative effects of multiple policy changes on all pollutants. Overall, the results demonstrate the role that stringent emissions caps and leakage controls play in limiting emissions that affect climate, air quality, and public health under a range of future conditions. The current context of the COVID-19 pandemic, interactions between air quality and health, and unknowns regarding energy use going forward suggest that there could be an even wider range of energy futures than originally contemplated here, underscoring the value of a policy choices that are robust to changing conditions and deliver defined climate and air quality benefits.

About the Analysis

The analysis in *Carbon Standards Re-examined* is based on emissions outputs from the Integrated Planning Model (IPM) from EPA's Regulatory Impacts Analyses and from our own IPM model runs conducted by ICF International. The assumptions for the updated CPP case are based on a policy case defined by the Natural Resources Defense Council. The IPM model represents a state-of-the-art energy sector model used by EPA and others to forecast the consequences of changing market conditions and policy assumptions across the U.S. power sector.

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