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Summary

This brief looks at the costs of implementing the EPA's Clean Power Plan. Specifically, it examines whether implementing the CPP on a state-by-state basis—that is, with each state meeting its own individual target for emissions reduction by 2030, rather than establishing regional targets—is economically efficient. The economic analysis uses data from electricity-generating firms participating in the Pennsylvania-New Jersey-Maryland (PJM) Interconnection to examine the relative economic efficiency of regional versus state-by-state implementation of the CPP. The research indicates that state-by-state implementation would yield the lowest electricity prices in 2030.

Keywords

energy policy, EPA, Clean Power Plan, cost efficiency, emissions, carbon, natural gas, electricity, CO_2, best available technology, BAT

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The Clean Power Plan (CPP) is the crowning environmental achievement of the Obama presidency, but a stay of proceedings has prevented the Environmental Protection Agency (EPA) from enforcing the rule's implementation since early 2016.

In February, the Supreme Court suspended the authority granted to the EPA under the Clean Air Act to compel states' preliminary CPP compliance. This action grants courts the necessary time to resolve legal challenges related to the new rule before any early-stage EPA enforcement efforts could de facto nullify a negative judgment against CPP implementation, which could be handed down in the coming months.[1] Presuming the EPA eventually will be able to move forward with the CPP—which is not guaranteed given the unprecedented scope of regulatory authority the agency is assuming—the conversation about the plan will return to the question of economic viability. In short, what will be the CPP's effect on long-term energy prices in the United States?

Although the federal government is seeking to address carbon pollution from power plants by setting a national goal for reduced CO2 emissions from fossil fuel-fired and natural gas-fired plants, each state must meet its own individual target for emissions reduction by 2030, with interim requirements each year between 2022-2029. On the surface, the absence of a single, national CO2 market for trading emission allowances would suggest that implementing the CPP on a state-by-state basis would lead to inefficiencies in curbing

SUMMARY

- This brief looks at the costs of implementing the EPA's Clean Power Plan. Specifically, it examines whether implementing the CPP on a state-by-state basis—that is, with each state meeting its own individual target for emissions reduction by 2030, rather than establishing regional targets—is economically efficient. The answer is yes.
- The economic analysis uses data from electricity-generating firms participating in the Pennsylvania-New Jersey-Maryland (PJM) Interconnection to examine the relative economic efficiency of regional versus state-by-state implementation of the CPP.
- Looking at natural gas capacity across regional and state-by-state implementations in 2030, the research shows that capacity in the state-by-state scenario (70 GW) is about 24% higher than the capacity in the regional scenario (56 GW). This translates to reduced CO2 prices in 2030--$27/ton (regional) and $15/ton (state-by-state).
- The key mechanism is investment. Compared to the regional scenario, implementing the CPP on a state-by-state basis leads to higher initial CO2 prices. But those higher prices increase incentives to invest aggressively in new natural gas capacity, using the best available technology in terms of emissions and efficiency. This, in turn, leads to an overall decrease in wholesale electricity prices—in fact, the research indicates that state-by-state implementation would yield the lowest electricity prices in 2030.

emissions (and it definitely leads to higher initial CO2 prices), thus increasing the economic cost of the CPP. But we offer two considerations. First, the existence of a single market for wholesale electricity mitigates the potential negative effects of separate state-level CO2 markets. Individual firms will make optimal new power plant investment decisions based on the distribution of production and CO2 prices across state markets, implicitly coordinating them in the process. Second, we simulate a model that shows that electricity prices can actually be lower by 2030 when implementation occurs state-by-state instead of regionally.

The model takes advantage of rich energy production data from electricity-generating firms participating in the Pennsylvania-New Jersey-Maryland (PJM) Interconnection, which operates the country's largest wholesale electricity market as the regional transmission organization (RTO) for 13 states across 20 zones.[2] By utilizing PJM as an example of a viable cohort of states that, under the new rule, could aggregate their individual emission targets and implement the CPP at a regional-level, we examined the relative economic efficiency of regional versus state-by-state implementation. Our preliminary findings were remarkable. By 2022—the first year of interim benchmarks—regional implementation leads to electricity prices of 5.7 cents/kWh, while state-by-state implementation results in prices of 8.6 cents/kWh. However, by 2030, electricity prices are 5.8 cents/kWh regionally versus 4.6 cents/kWh in a state-by-state scenario. This Issue Brief highlights how investment, in implicitly coordinating separate state CO2 markets, is the main mechanism for our findings.[3]

BACKGROUND

On October 23, 2015, the EPA published the Clean Power Plan Final Rule in the Federal Register after receiving and incorporating 4.3 million comments on the original proposed rule.[4] The CPP, though a federal plan, establishes state-level targets for cutting carbon emissions from the nation's largest polluter—power plants.[5] When aggregated, the individual state targets add up to the national goal: a 32 percent reduction in carbon pollution below 2005 levels by 2030 (see Figure 1). According to the EPA, the CPP has expected climate benefits of $20 billion and health benefits in the range of $14-$34 billion. The rule would facilitate the transition to cleaner, natural gas energy, promote investment in alternative energy technologies, and provide states the flexibility to meet their emissions-cutting goals. Ultimately, the EPA's chief concern is the federal 32 percent target that, if met, would constitute an important milestone in the fight against anthropogenic climate change.

If the stay of proceedings is lifted, the EPA will oblige states to submit unique Implementation Plans for ensuring that existing power plants within their jurisdictions achieve both interim and final CO2 targets. The rule offers three options for measuring progress and it highlights three so-called building blocks for meeting CCP targets based on the best system of emission reductions (BSER) available for CO2 emitting power plants (see Table 1). It also allows (but does not require) states to partner with other states when implementing their plans.

The state targets do not apply to new, modified, or reconstructed plants, which the EPA instead will regulate through standards and emissions limitations that are source- or unit-specific. For example, the final rule specifies a natural gas plant limit of 1000

NOTES

1 Some legal experts have suggested that the stay was granted to avoid an outcome similar to *Michigan vs. EPA*. In that case from 2015, preliminary clean air compliance measures – mandated by the EPA – cost states nearly $10 billion in exchange for only $4 million in direct health benefits before the Supreme Court ruled that the agency unreasonably interpreted the Clean Air Act. The Court decided that the EPA does need to consider costs when it implements regulations. For more, see Jonathan H. Adler, "Supreme Court puts the brakes on the EPA's Clean Power Plan", *The Washington Post*, February 9, 2016.

2 These thirteen states are Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Washington, D.C. There are nearly 1,000 electricity-generating firms that buy, sell, and deliver electricity through PJM's spot wholesale market, including ten strategic firms that participate in the lion's share of all exchanges and invest in all of the fuel-specific new capacity.

3 The primary source for this Issue Brief is our working paper: Jose Miguel Abito, Christopher R. Knittel, Konstantinos Metaxoglou, and Andre Trindade (2016), "Separate Markets for Externalities: Regional versus State-by-State Implementation of the Clean Power Plan".

4 Technically, the CPP refers both to a set of emissions targets applied to existing power plants (pursuant to Section 111(d) of the Clean Air Act) and to rules that are applicable to new energy sources as part of the "Carbon Pollution Standard for New Plants" (pursuant to Section 111(b) of the CAA). The final rule is available here: https://www.gpo.gov/fdsys/pkg/

TABLE 1: CPP EMPHASIS ON FLEXIBILITY IN MEETING STATEWIDE EMISSIONS GOALS

Measurement Options for Interim and Final Targets *(states choose one)*:

Option 1 - a rate-based state goal measured in pounds per megawatt hour (lb/MWh)

Option 2 - a mass-based state goal measured in total short tons of CO2

Option 3 - a mass-based state goal with a new source complement measured in total short tons of CO2

Strategies for Reducing Emissions *(states can use in any combination)*:

Building Block 1 - reducing the carbon intensity of electricity generation by improving the heat rate of existing coal-fired power plants

Building Block 2 - substituting increased electricity generation from lower-emitting existing natural gas plants for reduced generation from higher-emitting coal-fired power plants

Building Block 3 - substituting increased electricity generation from new zero-emitting renewable energy sources (like wind and solar) for reduced generation from existing coal-fired power plants

Source: Environmental Protection Agency

lbs of CO2 per MWh, below which firms will not have to pay for what they emit. In essence, this requires them to invest in the latest combined cycle technology. For coal-fired plants, the limit is 1400 lbs of CO2 per MWh, which is currently achievable only with carbon capture and storage technology—a technology that is in its infancy and presently cannot meet the new standards. The EPA cannot require energy producing firms to use explicit technologies, but even the best new coal-fired plants cannot meet the new emission limits by design. Some existing natural gas-fired power plants, however, do meet these new standards, leading to a policy question that remains unresolved, at least from the perspective of energy producers (see Policy Implications below).

IMPLEMENTATION SCENARIOS IN THE PJM VS. STATE-LEVEL MODEL

Policymakers generally have supported market-based mechanisms for addressing environmental externalities, such as carbon pollution, but the problem of coordinating various jurisdictions can quickly hamper implementation. Achieving state-level emissions goals under the CPP will require efficient implementation of one or more of the building blocks, as well as robust emissions trading, likely in the form of emission allowances, via (we assume) a perfectly competitive CO2 permit market. Inefficient implementation could significantly raise energy prices, which neither consumers nor policymakers want. Mitigating potential inefficiencies caused by state-by-state implementation of the CPP therefore depends on the ability of firms to reallocate electricity production across states. This is a complex challenge. States do not have unlimited capacity for generating electricity, and there are many firms striving to make optimal production and investment decisions in each state. These capacity limitations prevent existing plant output from being freely reallocated across states. However, output coming from new capacity investments can be located based on CO2 prices across states.[6]

We sought to discover what would happen to CO2 prices, wholesale electricity prices, and investment in new capacity under a number of different scenarios, so we constructed and estimated a model of electricity generation and investment for firms

NOTES

FR-2015-10-23/pdf/2015-22842.pdf

5 According to the EPA, fossil fuel-fired power plants are the largest source of U.S. CO2 emissions, accounting for 31 percent of total greenhouse gas (GHG) emissions, which itself is the largest source of pollution (82 percent) in the country.

6 All else equal, the CO2 price alters the merit order of plants with different fuel types (coal vs. natural gas), heat and emission rates, and it increases generating cost. Currently, since no emissions trading is occurring, the CO2 prices in question are shadow prices, or unofficial firm estimates of likely CO2 spot market prices.

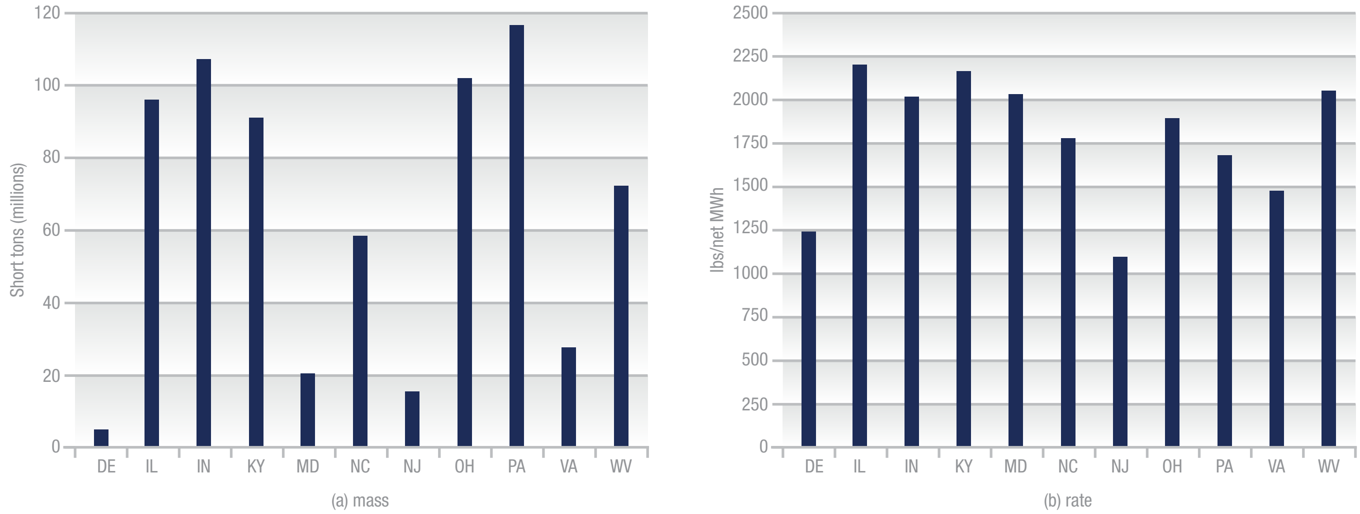
7 Data sources include EPA, PJM, EIA, FERC, SNL Energy, Evolution Markets, and other proprietary data. See Abito *et al.* (2016) for more information.

8 An argument for this assumption can be found here: Bushnell, J., S. Holland, J. Hughes, and C. Knittel (2015), "Strategic Policy Choice in State-Level Regulation: The EPA's Clean Power Plan", *NBER Working Paper 21259*.

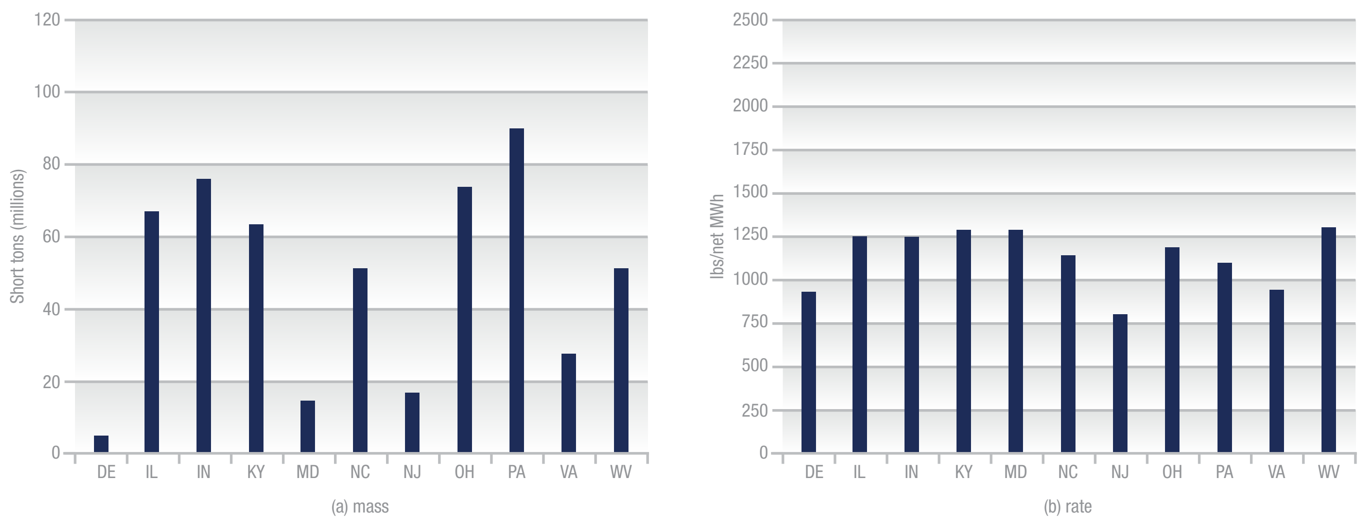
9 Electricity prices rose substantially in the fourth scenario where no new investment was allowed under a regional implementation.

FIGURE 1

CO2 TOTAL EMISSIONS & EMISSION RATES BY STATE, 2012



CO2 FINAL MASS & RATE TARGETS BY STATE, 2030



participating in the PJM wholesale market. We assume that all new investment will be in the current best available technology (BAT) for coal and natural gas plants, both because the CPP mandates this and because such an investment maximizes firm profit. The scenarios are as follows:

1. *Baseline*: Business-as-usual without CPP targets (e.g., courts rule against the EPA and prohibit CPP implementation).
2. *Regional Implementation:* One PJM-wide carbon market and CO2 price to achieve a regional target.
3. *State-by-State Implementation:* State-based carbon markets and CO2 prices to achieve CPP state-level targets. Under this scenario, states cannot trade allowances with other states, even within the same firm. All state markets are linked via the PJM wholesale market for electricity, and all markets must clear simultaneously.
4. *Regional Implementation ex-Investment:* One PJM-wide carbon market and CO2 price in an environment with no new investment (assumes coal- and gas-fired capacity at 2012 levels).

A final note on the model: The CPP affects supply and investment decisions (and firm profits) by increasing the cost of generating electricity from fossil fuels and changing the relative prices of coal and natural gas. To accurately capture the CPP's effect on firms' decision-making, we needed to have a rich model of firms' costs and how these costs evolve as they add new capacity. Since firms have different portfolios of plants, with different efficiency levels, different fuel types, and different capacities, our model uses all available data on heat rates, emission rates and operating and maintenance costs, thus preserving the diversity inherent in the industry.[7]

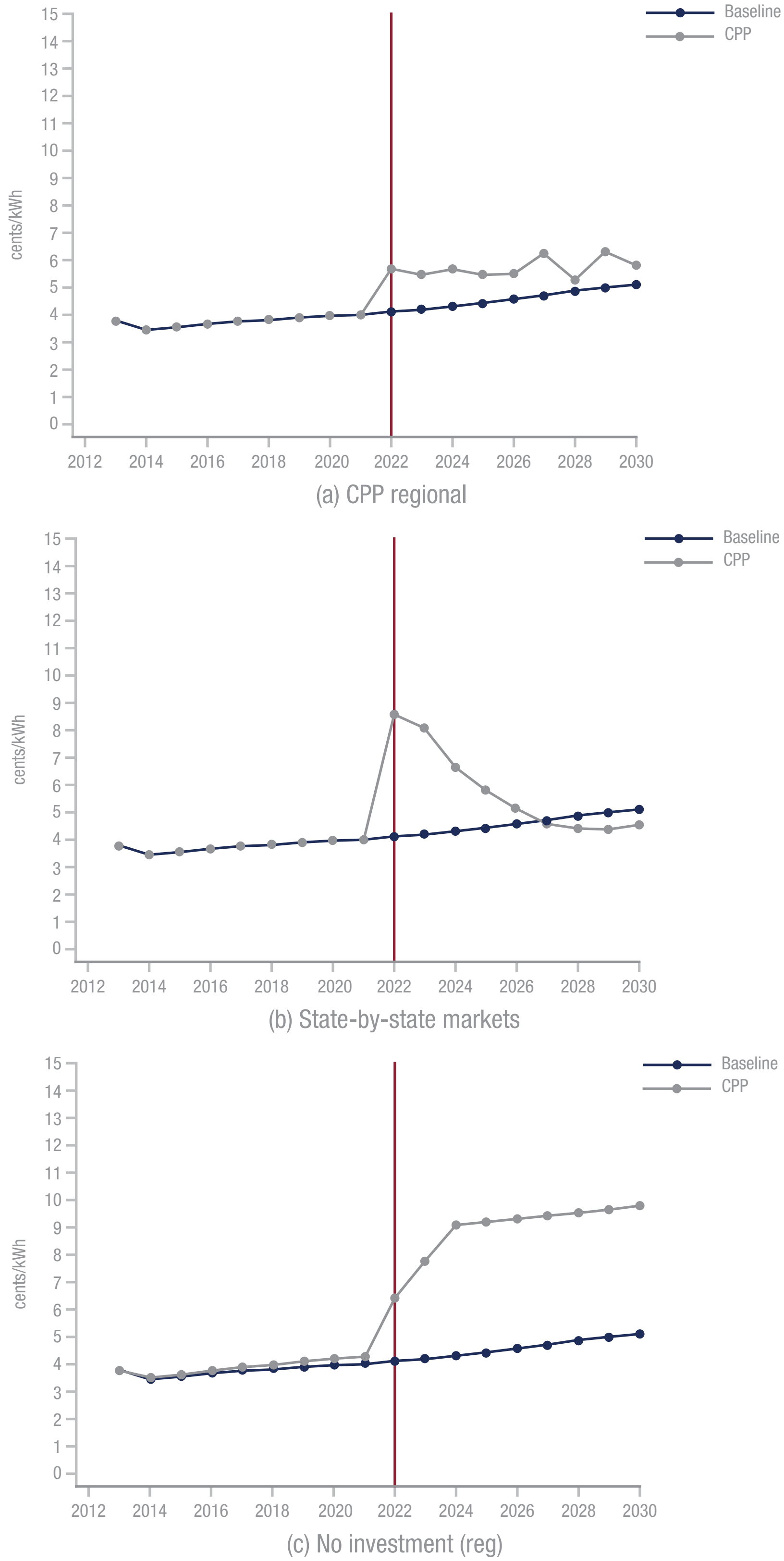
RESULTS AND POLICY IMPLICATIONS

The target CO2 emission rates in the CPP final rule are either mass-based (total CO2 short tons) or rate-based (lbs/MWh). We assume that all states choose mass-based targets.[8] Implementation begins gradually and CO2 emissions decrease each year until 2030, after which time we assume emissions remain constant. Even without the CPP, the model predicts that firms will invest only in new natural gas capacity and not in coal.

If there is no CPP in 2030, natural gas capacity is just 33 GW, as generation from coal steadily increases while electricity demand increases despite no new investment in coal capacity. Once firms face a positive CO2 price, generation from coal falls sharply, especially in the state-by-state scenario.

If the CPP is implemented, its effects are significantly different, depending on whether there is regional or state-by-state implementation. Comparing natural gas

FIGURE 2



capacity across regional and state-by-state implementations in 2030, capacity in the latter (70 GW) is about 24% higher than the capacity in the former (56 GW). In terms of 2030 CO_2 prices, this translates to $27/ton (regional) and $15/ton (state-by-state). As noted earlier, the initial CO_2 price is higher under the scenario of state-by-state implementation. This increases the incentives to invest in new natural gas capacity, which reflects the best available technology in terms of emissions and efficiency. High CO_2 prices encourage firms to invest much more aggressively in order to retire old, inefficient capacity from the merit order, leading to an overall decrease in wholesale electricity prices (see Figure 2). Remarkably, electricity prices are even lower with the state-by-state implementation compared to the regional scenario by 2030. As noted in the opening of this brief, by 2030, electricity prices are 5.8 cents/kWh regionally versus 4.6 cents/kWh in a state-by-state scenario.[9]

With regional implementation, BAT capacity accounts for 31% of total generation by 2030. In contrast, 45% of generation comes from BAT capacity under state-by-state implementation. Without CPP, BAT capacity accounts for less than 6% of total generation.

Considering the expected public health and environmental benefits garnered by a shift towards new BAT capacity, and noting that the lowest electricity prices in 2030 come as a result of state-by-state implementation, there is reason to believe the Clean Power Plan is economically beneficial. However, some questions remain. For instance, there is an ongoing debate about whether the location of new BAT capacity matters, as different sections of the Clean Air Act offer conflicting answers. But the primary concern is that existing natural gas plants that meet the new emissions standards, even if they do not represent BAT, may be facing artificial costs under the CPP. This (significant) subset of "old" yet standard-meeting plants must pay for emissions, according to the final rule, while new plants will not have to pay for emissions, as they only have to ensure they emit less than the new limit. The resolutions to these questions could still dramatically alter the final landscape.

CONCLUSION

If the stay on the CPP is lifted and policymakers refocus their attention on the cost of implementing the new rule, our research indicates that state-by-state implementation would not be a bad alternative to regional implementation (e.g., a cohort of PJM Interconnection states) in terms of wholesale electricity prices (and therefore CO_2 prices in a competitive permit market) and new capacity investment. Because investment implicitly coordinates separate state CO_2 markets, it is the key to evaluating CPP implementation. Our results on new BAT investment under the four implementation scenarios speak for themselves.

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