Power Sector Transformation through CO_2 Emission Rate Regulation in U.S.

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This paper reviews America's carbon emissions standards from existing power plants, known as the Clean Power Plan (CPP). The CPP is by far the largest and most important climate change mitigation policy in the United States, loaded with new mechanisms to limit carbon emissions and promote low-carbon power sources at the same time by setting standards in the form of an adjusted emission factor. The adjusted emission factor allows the CPP to integrate different power sources such as coal, gas and renewable, and even energy saving into a single indicator for carbon efficiency, which guides the U.S. power pool into a more carbon efficient fleet as a whole. This approach integrates all power sources under a single indicator of an adjusted emission factor and creates a picture of the future of the power generation mix as a whole while addressing challenges such as power price and reliability.

1. Introduction

In August 2015, the U.S. Environment Protection Agency released the final version of the Clean Power Plan to regulate carbon dioxide emissions from existing fossil fuel power plants. The CPP is positioned as the most important among U.S. climate change policies and calls for the largest GHG emissions reduction in the U.S. intended nationally determined commitments (INDC) submitted to the United Nations. This paper summarizes the CPP mainly in comparison with its initial draft made in 2014, explains the potential of technologies assumed in the CPP and mechanisms for CPP implementation and extracts implications about the reduction of carbon emissions in the power generation sector.

2. Overview of CPP

The CPP regulates existing fossil fuel power plants and sets state-by-state adjusted emission factor targets that take into account not only fuel switching but also the potential of renewable energy. After the initial draft was released in June 2014, revisions given in Table 1 were made through 4.3 million public comments for the final version. Revisions range widely, including 1) technology potential changes, 2) the postponement of the CPP compliance period to provide more time for preparation, 3) additional measures to secure electric system reliability, 4) the expanded market mechanism, 5) the introduction of incentives for early actions and 6) a federal plan as a model for states. Despite many revisions, a carbon dioxide emission cut for 2030 was expanded from the initial draft to 32% (from 2005) (see Figure 1 for the emission pathway).

Table 1 Overview of CPP

	Proposed Plan	Final Plan
Regulation target	・Capacity is 25 MW or more. ・Fossil fuel combustion capacity is 260 GJ/h or more. ・Construction started before January 8, 2014.	
Implementation	The EPA sets state-by-state targets for implementation by states.	
Compliance period	・Interim target: 2020-29 average ・Final target: 2030 (to be maintained thereafter)	・Interim target: 2022-29 average ・Final target: 2030 (to be maintained thereafter)
Reasons for targets	1.Coal efficiency improvement 2. NGCC operating rate improvement 3. Renewables/ existing nuclear plants 4. Energy	1.Coal thermal efficiency improvement 2.NGCC operating rate improvement 3. Expanding renewables

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	conservation	
Market mechanism	Emission allowance (tCO_2) trading	Emission allowance trading (tCO_2), Emission rate credit trading (MWh)
Submission of state plan	By September 2016 Extension: One state (1 year) Multiple states (2 years)	By September 2016 Extension: 2 years after September 2016
Emissions reduction	30% from 2005	32% from 2005
Components only in final plan		
Early action	Issuing credits for renewable energy and energy conservation projects in 2020 and 2021	
Stale supply	States are required to address reliability assurance in their plans.	
Model plan	A federal plan is made as a model.	

Source: EPA documents

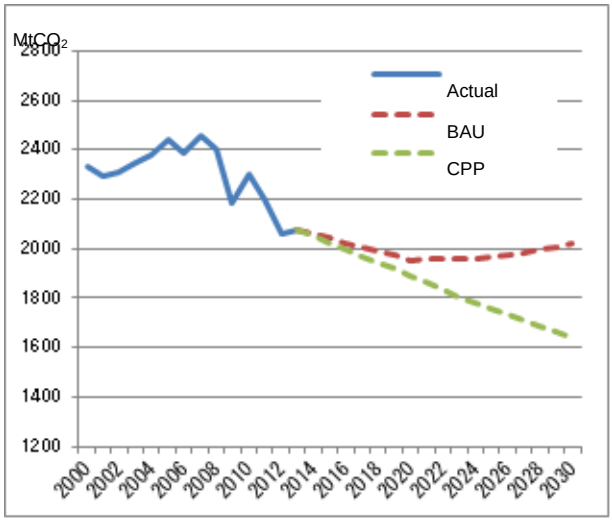

Figure 1 Expected CO_2 emission cuts

Source: EPA documents

3. Setting targets

As indicated by the following equation, the CPP, while regulating a CO_2 emission factor (tCO_2/MWh) as a weighted average for existing fossil fuel power plants in each state, includes renewable energy potential into targets to pursue CO_2 emission cuts involving non-fossil fuel power plants as well as fossil fuel plants.

$$EF = E/(GE_{Fossil} + GE_{RE})$$

EF: Emission factor (tCO_2/MWh)
E: Fossil plant CO_2 emissions
GE_{Fossil}: Fossil plant power generation (MWh)
GE_{RE}: New renewable energy power generation (MWh)

In setting the state-by-state targets, the EPA divided the U.S. mainland into three interconnected regions (East, West and Texas) and computed their respective potential to cut emissions. The following three technologies are used as the basis for emission standards.

(a). Improvement of thermal efficiency at coal power plants
(b). Improvement of capacity factor for natural gas combined cycle (NGCC) power plants (raising the net summer capacity factor from the present U.S. average of 40-50% to 75%)
(c). Continuation of 2010-14 renewable energy power generation growth until 2030

The EPA estimated these three technologies' effects for the East, West and Texas (see Table 2) to compute state targets.

Table 2 Potential of technologies as reasons for setting targets

	Thermal efficiency improvement for coal power plants	NGCC power generation (Increase)	Renewables
East	4.3%	988TWh (253TWh)	438TWh
West	2.1%	306TWh (108TWh)	161TWh
Texas	2.3%	204TWh (66TWh)	107TWh

Source: EPA documents

As the above potential calculation has been made only for setting targets, each state is allowed to use other electricity sources than cited above and other CO_2 emission reduction measures than the above.

4. Implementation method

The CPP provides tools to draw the potential of each electricity source when each state develops an implementation plan and puts it into practice.

Renewable energy: The CPP, though regulating fossil power sources, allows an increase in renewable energy power generation (including new nuclear power generation) within the compliance period to be added to power output as the denominator for computing the emission factor in the following equation.

$$EF = E/(GE_{Fossil} + GE_{RE} + ERC)$$

EF: Emission factor (tCO_2/MWh)
E: CO_2 emissions from fossil electricity sources (tCO_2)
GE_{Fossil}: Fossil power output (MWh)
GE_{RE}: New renewable energy power output and energy conservation (MWh)
ERC: ERCs for renewable energy output and energy conservation (MWh)

Power output with renewable energy can be traded as emission rate credits (ERCs) and distributed through the market mechanism. As the compliance period has been postponed for two years from the initial draft, ERCs are allowed to be issued for renewable energy output and energy conservation in 2020 and 2021 to promote early actions.

Energy efficiency: Electricity corresponding to the energy efficiency may be added to power output as the denominator for computing the emission factor, as is the case with renewable energy. In the case of emission factor target, energy efficiency will suppress electricity demand, resulting in CO_2 emissions reduction.

Emission allowance trading: The emission factor target can be converted into a mass-based target (tCO_2) by multiplying by projected power output. This will enable emission allowance trading. The EPA has recommended the implementation of emission allowance trading to optimize emission reduction costs. Emission allowance trading depends on state-by-state CPP implementation plans. If all states adopt emission quota trading, it will create a nationwide carbon market.

Multi-state implementation: CPP implementation involving multiple states is expected to enable cost effective emission reduction through interstate cooperation and sharing of renewable energy potential in a wider area. The EPA also recommends emission allowance trading to be conducted in multiple states.

5. Policy effects

The EPA has analyzed each above electricity source's potential and the results of relevant policy measures in its Regulatory Impact Analysis.

The analysis projects a U.S. electricity mix under the CPP, as shown in Figure 2. First, energy conservation under the CPP will reduce electricity output from the BAU (business as usual) level. Energy conservation is expected to make further progress under the CPP. While natural gas power generation under the CPP is expected to indicate no major change from the BAU level, coal power generation under the CPP is projected to decline by 23% from the BAU level.

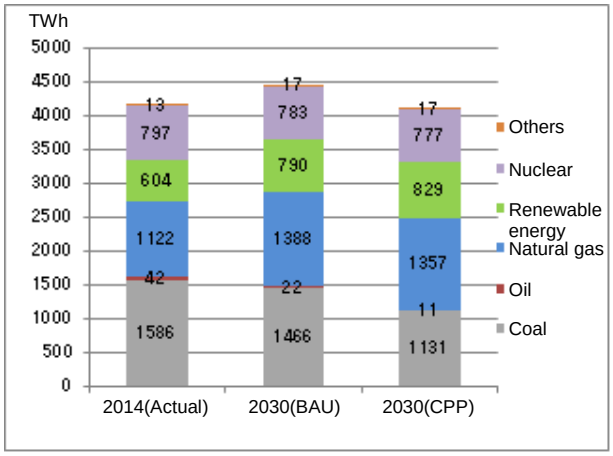

Figure 2 Electricity mix changes under CPP

Source: EPA Regulatory Impact Analysis

As shown in Figure 3, the CPP's impacts on electricity prices are analyzed on a region-by-region basis according to the division by North American Electric Reliability Corporation. While impacts differ from region to region, electricity prices are projected to increase in many states. The nationwide average electricity price is projected to be 3% higher than the BAU level in 2020 and become almost the same as the BAU level in 2030.

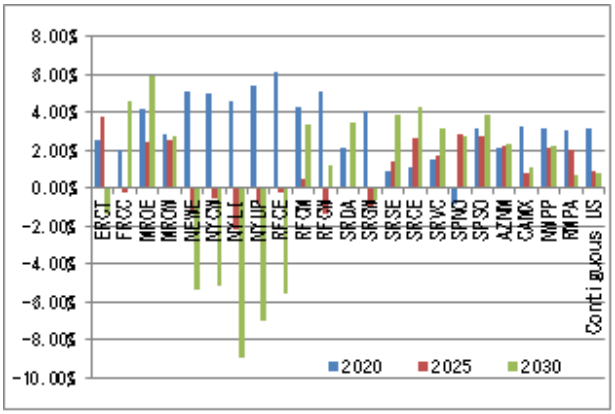

Figure 3 Electricity price changes from BAU

Source: EPA Regulatory Impact Analysis

Meanwhile, electricity spending per household is expected to decline in 2030 as the CPP promotes energy conservation.

6. Implications

Four major implications can be drawn from CPP's technology potential and the CPP implementation tools.

Adjusted emission factor's presentation of potential: The CPP uses the adjusted emission factor to dig deeper into the potential of emissions reduction through expansion of renewable energy. Since all grids receive electricity from various sources that complement each other, focusing on fossil electricity sources alone cannot lead to depicting a desirable picture of grids. By covering all electricity sources with the adjusted emission factor, however, the CPP indicates the future electricity generation mix.

Importance of energy efficiency: Cost-effective energy efficiency can be an important measure to comply with the CPP for two reasons. First, the competitive U.S. wholesale electricity market dispatches from sources with the lowest marginal costs. Therefore, energy efficiency is curves generation from electricity sources with higher marginal costs, contributing to the suppression of electricity prices. Second, the CPP provides targets in the form of adjusted emission factors, allowing the promotion of energy efficiency to contribute to reducing emissions quantitatively. As indicated in Figure 1, improvement of adjusted emission factors is required along with reduction of electricity demand to achieve the target emission reduction of 32% in 2030. In this sense, "unused electricity" is as important as fuel switching and renewable energy as electricity sources.

Roles of the emission allowance trading: As the shale revolution made cheap natural gas abundantly available, fuel switching is expected to make progress even in the BAU case. Some renewable energy electricity sources are competitive enough to be accepted in the wholesale electricity market. In addition, fuel switching through a carbon pricing can be implemented to draw the potential of the NGCC and renewable energy. Before the CPP implementation, nine northeastern states have operated the Regional Greenhouse Gas Initiative (RGGI) as an emission trading system since 2009. California has implemented a cap and trade system covering the industry sector as well as the power generation sector since 2013. These systems may be affected when the CPP is implemented. In the meantime, other states could participate in these systems in response to the CPP. Particularly, the RGGI has been implemented in multiple states and targets facilities with 25 MW in power generation capacity as does the CPP. Therefore, the RGGI may be useful for implementing the CPP. On the other hand, the Californian system targets other industries as well as the power generation sector and may have to be revised under the CPP.

Multi-state implementation: While states are significant as administrative districts, grids are always operated beyond state boundaries. Implementing regulations within a framework meeting the regional electricity system rather than within each state may be more reasonable in many areas. This stands not only for a regional use of renewable energy potential but also for efficient use of power plants. For example, a coal power plant that is bound to be shut down due to a low capacity factor in a single state could avoid a shutdown by taking advantage of its surplus capacity for fulfilling electricity demand in a wider area than a single state. In their respective analyses of the initial CPP draft, the Southwest Power Pool, the Midwest Independent System Operator and the PJM Interconnection concluded that multi-state CPP implementation would be far more cost-effective than single-state implementation. This is because multiple

states' sharing of potential low-carbon electricity resources in a state could reduce costs.

7. Future challenges

The above provided potential and tools for the reduction of emissions under the CPP. However, there are three challenges for realizing the CPP.

Uncertainties about natural gas prices: If natural gas prices remain low, fuel switching to natural gas will hold down CO_2 emission reduction costs. If natural gas prices rise, however, fuel switching for emission cuts will cost more. Renewable energy costs are expected to decline due to technological innovation. No rise is predicted in renewable energy costs. As natural gas prices are uncertain, CPP compliance costs could exceed an initial assumption depending on gas market developments.

Electric system reliability: The CPP is expected to reduce the share of coal power plants by more than 20% from the BAU level. In this respect, the Electricity Reliability Council of Texas (ERCOT) has pointed out that the rapid decommissioning of coal power plants could affect reliability of the grid. Such risk may be solved quickly for grids for which wide-area capacity markets have been developed. However, other grids will have to address such risk.

Electricity prices and spending: In its assessment of the CPP's impacts after the release of the first CPP draft, the Energy Information Administration estimated that an electricity price hike through the CPP would be greater than projected by the EPA. Similar estimates could arise as relevant organizations analyze the final version of the CCP. Therefore, measures to prevent any sharp electricity price hike and a mechanism for steady energy conservation will have to be developed quickly.

8. Conclusion

As explained above, the CPP has various elements with many challenges and uncertainties about its implementation. In addition, some states have filed suits seeking to stop the CPP. Whether the CPP would be put into practice will also depend on the 2016 presidential election results to a certain extent. A separate analysis may be required on relevant moves of stakeholders.

However, the CPP takes advantage of the adjusted emission factor to reduce carbon from all electricity sources and draw a picture of a cleaner electricity generation mix. The CPP also indicates a direction of future power generation sector regulations as a case where comprehensive, fine-tuned consideration is given to system reliability and economic efficiency for reducing emissions in the power generation sector.

Reference

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