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The state of the states
Data-driven analysis of the US Clean Power Plan

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ABSTRACT

On August 3, 2015 the US Environmental Protection Agency finalized the Clean Power Plan (CPP) which aims to reduce CO_2 emissions from the electricity generating sector by 32% of their 2005 levels by the year 2030. With the rule now finalized, in order to understand how the impact of this will unfold, we need to understand the factors that may influence how the electricity sector evolves given the targets that must now be met. To both identify and understand these relevant factors, we have completed an analysis of US electricity generation data for the period between 2001 and 2014. The result is a detailed fingerprint of the sector per state based on monthly data at the resolution of individual generators. This analysis demonstrates that several "building blocks" or decarbonization strategies encouraged by the CPP are already being utilized in the period analyzed across US states, resulting in CO_2 emissions that have already dropped 12% in the period studied.

Furthermore, we show how the states exhibit considerable differences due to the complexity of their existing generation portfolios, geography, climate and demand patterns. We also examine to what extent the targets of the CPP may impact the most polluting part of their generation portfolios, and how this relates to developments with shale gas and state policies. We then conclude with an overview of which factors may either enable or hinder how the goals of the Clean Power Plan will be met.

Contents

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The US electricity sector emits 2 billion tons of CO_2 yearly,[1] accounting for 38% of the country's total energy related CO_2 emissions [33]. Addressing climate change will clearly require changes to this sector. A challenge is that states vary widely in terms of their mix of natural resources, their power systems, network infrastructures, policies and demand patterns. Decarbonizing requires understanding and navigating the complexity of these factors, and we desire to unravel these further through a data-driven analysis which provides sophisticated fingerprints of the electricity sector per state.

Climate change concerns and the Kyoto Protocol (1997) have stipulated companies, innovators, and individual countries to improve the efficiency of their thermal power plants, shift from coal to natural gas or nuclear, develop systems for combined heat and power, and to develop alternative sources, such as biomass, solar, wind and hydro power. While the US never ratified the Kyoto Protocol, US Presidents have consistently worked on developing decarbonizing capability. The government has consistently monitored the US positions with regard to resources, and committed enormous funds to among others, the US Department of Energy, the EPA and several large government agencies and university-run research programs in the (clean) energy and power domain. In addition to efforts at a national level, several initiatives are underway or in consideration at the state level [15]. These include the Regional Greenhouse Gas Initiative (RGGI)[2] involving the Northeast and Mid-Atlantic states, the Midwestern Greenhouse Gas Reduction Accord, and the California Cap-and-Trade Program.[3]

To encourage decarbonization, on August 3, 2015, the US Environmental Protection Agency (EPA) finalized the Clean Power Plan (CPP) [30], which aims to cut carbon emissions from power plants by 2030 to 32% of their 2005 levels. The plan has been met with mixed responses. Unsurprisingly, environmentalists and the renewable energy sector are largely in favor, while the coal industry and representatives from coal states are generally opposed to it [5,28]. Opponents of the plan are challenging its legal justifications, which hinge on the interpretation of the powers that are given to the EPA by the Clean Air Act [23,48], with others questioning the health claims made in the plan and advocating for greater transparency of the plan's data sources and research [25].

To understand the plan's implications given the complexity of the US electricity sector, we analyzed data published by the Energy Information Administration (EIA),[4] containing monthly data on individual Electricity Generating Units (EGUs) from 2001 until 2014.[5] In examining 1.6 million observations, we uncover important patterns in the development and operational characteristics of the electricity sector, both at national and state levels, and investigate the following questions: How does electricity generation compare across the states, and what important changes have taken place over the last decade? To what degree do we already observe progress towards the targets specified by the plan, and through what changes can we see this being achieved? Furthermore, what does the data reveal about factors which will play a role in how the impacts of the Clean Power Plan unfold?

1. The ongoing decarbonization of the US electricity sector

Over the past decade, US electricity generation has been relatively stable and CO_2 emissions have been decreasing along with the CO_2 intensity of generation (Fig. 1a). A major factor is that generation from natural gas is increasing at the expense of that from coal, largely due to lower gas prices resulting from increased availability of shale gas [32], which has in turn led to lower CO_2 emissions from the power sector [6]. Furthermore, installed capacity for solar and wind has been increasing significantly, although still constituting a small fraction of total generation. A remarkable trend is that solar capacity is increasing so rapidly that generation for the *winters* of 2014, 2013 and 2012 were all greater than or equal to that during the *summers* 18 months previous.

2. Implications of the Clean Power Plan for US states

The CPP proposes a set of state-specific goals expressed in terms of adjusted output-weighted-average CO_2 emission rates. These are determined using a standard formula[6] fed with state and region-specific information, such as the characteristics of the state's current generation portfolio and the technical possibilities for reducing emissions. States would be required to meet the proposed targets by 2030, but would be free to choose from a mix of three strategies or "building blocks".

The states vary widely in their generation portfolios, and have different opportunities related to factors such as population, geography and economics. Some states have a long history of heavy reliance on renewable energy sources; some have more recently embraced renewables, natural gas and other forms of cleaner energy sources; others have stuck largely with coal-based generation. Change is not always fast as power plants have very large capital costs and long lifetimes. Coal and nuclear plants may be operational for more than forty years, and several operational hydropower plants are over a hundred years old.

Fig. 2 gives a visual overview of the CPP targets by showing the rank of the states in terms of emissions rates and the magnitude of improvements proposed. As shown by the lines for the CO_2 intensity of coal and natural gas, a switch from coal to natural gas would enable many states to reach their goals even without a major focus on renewables.

3. Building blocks of the clean power plan

The three CPP "building blocks" have been used to determine state-specific goals, and states are free to choose from a combination to achieve their targets. The proposed blocks are:

[1] As of 2013.
[2] http://www.rggi.org/
[3] http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm
[4] http://www.eia.gov/electricity/data/eia923/
[5] The data contains diverse information such as the fuel type and heat input for electricity generation, which we have coupled with fuel emissions factors (in terms of kg CO_2/MMBtu) to calculate the total CO_2 emissions. The net electricity generation is also recorded, so the CO_2 intensity per MWh can also be derived. These do *not* include life-cycle emissions, such as greenhouse gas emissions from coal and (shale) gas extraction or methane leakage.
[6] Described starting on p. 771 of United States Environmental Protection Agency [30].