Forecasting Carbon Emissions in Seven Eastern States of the United States; The Effects of Coal Deregulations

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Abstract: The 2008 through 2016 were the years of implementation of increasingly restrictive regulatory policies on climate change, and particularly on carbon emissions by coal-burning power plants. Some of these regulations were imposed by states (in the form of Renewable Portfolio Standards, RPS) and majority of them were imposed by Obama Administration. These regulations, among other factors, resulted in a significant drop in the U.S. total emissions; 12% drop from 2007 to 2016. (See Fig. 1) The current Administration has taken several actions in reversing, relaxing, or repealing many of these regulations, and particularly regulations on use of coal in electricity generation. In this paper we present two ARIMA models to forecast the potential effects of these deregulations on future carbon emissions of states of Ohio, Pennsylvania, North Carolina, Tennessee, Kentucky, Virginia, and West Virginia. These states were chosen in part because they rely heavily on electricity generated from coal and their RPS targets are among the lowest in the nation.

Introduction

Taking the United States out of the historic 2016 International Paris Agreement is only one among a long list of actions taken by the current Administration in reversing many years of climate policies, especially those implemented by the Obama Administration (Adler, 2011) and (McCarthy and Copeland, 2016). The list of the deregulatory actions taken by the current Administration in coal industry include: (Brookings Institution, 2019) and (National Geographic, 2020): relaxing the rules on emission of greenhouse gases in new coal-fuel power plants, relaxing the rules on producing mercury and other air-toxins by coal-burning power plants, repealing Clean Power Plan, and postponing enforcement of many Environmental Protection Agency (EPA) regulations.

The total U.S. carbon emissions had been on a declining trend in the past several years, as shown in Fig. 1 (Energy In Depth, 2017).

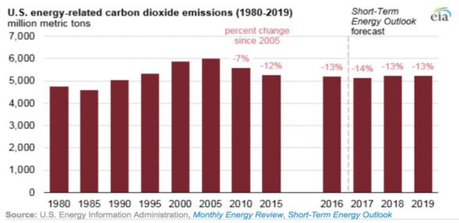

Figure 1: The US Total Carbon Emission.

The massive deregulations by the current administration is expected to reverse the recent decline in the U.S. emissions resulting in substantial increase in the next several years. The National Oceanic and Atmospheric Administration in its 2018 Report on "Climate Change: Current and Projected Impacts on the U.S." called for the need for removal of existing carbon from the atmosphere to prevent the projected climate disasters by 2050 (NOAA, Fahey 2018). In light of this warning, it is imperative that we investigate the effects of coal deregulations on carbon emissions, especially in those states in the United States who rely heavily on electricity generation from coal.

We (Khoie and Calderon, 2019) previously presented four ARIMA models for forecasting the future trends in carbon emissions of the three states of Hawaii, California, and Colorado whose RPS laws set the most ambitious renewable targets, and the State of Florida, which has no RPS laws. In this paper, we present ARIMA models for forecasting the future trends in carbon emissions of seven neighboring eastern states. These states are: Ohio, Pennsylvania, North Carolina, Tennessee, Kentucky, Virginia, and West Virginia. These states were chosen for two reasons: (a) they either do not have any RPS laws (KY, TN, and WV) or their RPS targets are among the lowest in the nation , and (b) they rely heavily on electricity generated from coal (U.S. EIA, 2018).

The ARIMA Models:

The general form of the ARIMA model is given by:

$$y_t = \mu + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$$

Where:

y_t is the predicted value for year t,

y_{t-1} is the predicted value for year $t-1$,

μ is a constant term for a non-zero average trend,

φ_p terms are autoregressive term (AR),

p is the order of autoregressive process,

θ_q terms are moving average parameters (MA),

q is number of lagged forecast errors in prediction model,

ε_q terms are forecast errors.

Further details of the ARIMA model can be found in (Khoie, Calderon, 2018)

Results:

In the 8 years between 2001 and 2008, the percentage of combined electricity generation from coal in all seven states hovered around 70%. In the next 8 years (2008 to 2016) the percentage of electricity generation from coal dropped from 70% in 2008 to 44% in 2016. This was a substantial drop in coal generation over the 8 years of the Obama Administration. (See Fig. 2)

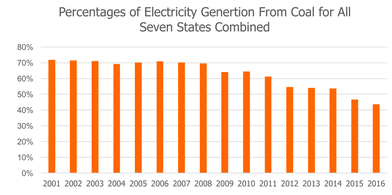

Figure 2: Percentage of coal generation in all seven states.

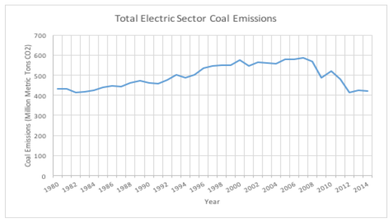

Figure 3: Combined Coal Emissions in all seven states .

In the meanwhile, the total emissions of the electricity generation from coal in all of the seven states (shown in Fig. 3) peaked at 588 MMT in 2007 after which it declined to 421 MMT in 2014 which is a 29% drop in emissions. This drop is significantly higher than the national average drop of about 11% during the same period.

Fig. 4 Shows the forecast results of ARIMA (0,2,1) model for emissions of electricity generation from coal in all seven states through 2025. These results are based on emission data from1980 through 2007 which exclude the emission data of the 2008-2014 era. These results show continued increase in emissions if the regulatory policy changes of 2008-2014 had not taken effect. The range of data for 80% and 90% confidence levels are also shown.

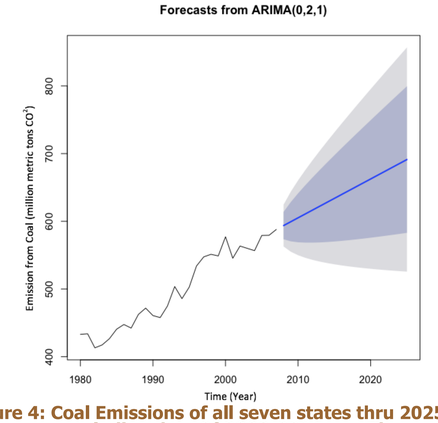

Figure 4: Coal Emissions of all seven states thru 2025, excluding data 0f 2008-2014 era. The results with 80% thru 90% confidence levels are also shown.

Results:

Fig. 5 Shows the forecast results of ARIMA (0,2,1) model for emissions of electricity generation from coal in all seven states through 2025. These results are based on emission data of 1980 through 2014 and include the data for the 2008-2014 years in which increasingly more restrictive federal regulations and especially on coal power generation were implemented. These results show declining trends in emissions in years 2015-2025 in response to the regulatory policy changes of 2008-2014. A comparison of the two results clearly shows the effect of deregulation in coal emissions.

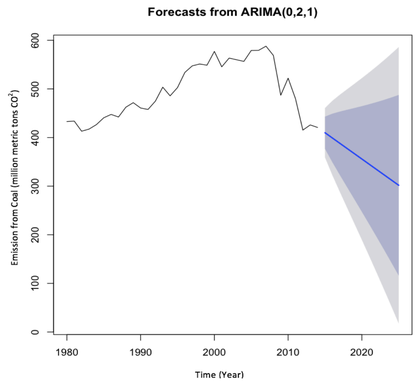

Figure 5: Coal Emissions of all seven states thru 2025, including data of 2008-2014 era. The results with 80% thru 90% confidence levels are also shown.

Conclusions:

The short-term energy outlook forecast by Energy Information Administration (shown in Fig. 1 (Energy In Depth, 2017)) indicates that the total U.S. carbon emissions in the years 2018 and 2019 are on the rise. This trend, and potential acceleration of such trend as result of continuation of the deregulatory environment created by current Administration are in sharp contrast to the warning issued by the current National Oceanic and Atmospheric Administration. To prevent projected climate disasters by 2050 (NOAA, Fahey 2018), we need to remove existing carbon from the atmosphere. With that as our goal, projected emission in 2025 would be too much emission to have to be removed from the atmosphere.

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