Discovering Market Opportunities for Green Technologies in the Existing Electricity Market

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Abstract

We analyzed pollution data and electricity market supply and demand to conclude that adopting more renewable energy sources in particular states is the most efficient way to meet growing electricity demand while simultaneously limiting the spread of pollution.

1 Introduction

As part of the Paris Agreement, the United States pledged to reduce its carbon emission 24% by 2025 in an attempt to keep global warming less than $2°C$. The economy must be significantly decarbonized to meet these goals. The best hope for such decarbonization comes from using renewable resources to generate electricity as such technology already exists and is economically feasible. Additionally, electricity from renewable resources will allow for further decarbonization in the transportation sector, as electric cars are on the rise.

One of the most cost-effective ways of decarbonizing electrical power generation is making sure that growing electric power demand is met with renewable, rather than carbon-based, energy. This paper develops an econometric model of the electricity market to explore this approach to decarbonization by forecasting future trends of supply and demand of electricity and then determining the greatest market opportunities for introduction of green technologies. Our rationale rests on the understanding that the greatest challenge we face in coming years is not the technology itself, but rather its efficient implementation within a world plagued with aging, primitive energy solutions.

2 Topic Question

In our analysis, we hope to answer the following question:

How can we simultaneously meet the growing demand for electricity while containing the spread of pollution, and how do we do so as efficiently as possible?

To address this question, we must consider both the externalities of energy production and the demand for electricity.

3 Pollution Analysis

To our analysis, we began an exploration into the air pollution data from the U.S. Environmental Protection Agency Air Concentrations dataset. Figure 1 provides a visualization of the trends in air pollution that we discovered.

The red dots show air filters measuring air pollution. The size and vividness of the color of the dots are proportional to the intensity of the air pollution at each filter.

We can see that air pollution was severe in the Midwest in 2000 as a result of robust industrial activity. By 2008, air pollution decreased due to more stringent environment regulations and an overall decrease in manufacturing after many U.S. manufacturers pulled out of industrial production following increased competition with China upon its entry into the World Trade Organization in 2000. The decrease in manufacturing lead to less electricity demand as well as less pollution from power production and the manufacturing process. In 2017, shown in the third map, we see the effects of further decreased manufacturing due to the 2008-2009 recession, continued competition with China, and continued tightening of air pollution regulations. Specifically, these social trends have brought air quality in the Midwest to safer levels. However, we also see a proliferation of detectable air pollution levels across the United States. While the intensity of air pollution in the Midwest has been on the decline, detectable air pollution levels have spread across the U.S.

While air pollution does seem to be decreasing in intensity, the fact that it appears to be spreading is still a cause for concern. However, it also reveals an important insight. The tracking of pollutants across the U.S. correlates strongly with the share of the electricity market as renewable energy sources become more predominant.

4 The Electricity Market

Hence, we follow by pinpointing the aspects of the electricity market that may offer the greatest insight into opportunities for market growth through renewable energy. At the root of the air pollution problem is simply man's quest for more electricity. To address the electricity problem, we aim to understand the existing electricity market. We employed the SARIMAX model to forecast future demand and supply of electricity. We also used polynomial regression to confirm our results.

In doing so, we made a few choices to better model this information. First, demand was represented as $D = E/P$, where E is expenditure of a state and P is the population of that state. Thus, demand was modeled as the expenditure per capita. Supply, on the other hand, was modeled as the production of electricity per year.

Then, we used SARIMAX to forecast the next 15 years of supply and demand. After scaling values of data prior to 2017 to within the same range, we found the difference between forecasted supply and forecasted demand in 2030. These values were represented as our difference scores, and represent the forecasted magnitude of the difference between supply and demand of electricity by 2030.

Our rationale in finding these values is that these states represent the markets with greatest opportunity for the development and implementation of green technologies. By approximately 2030, the OECD predicts that green technology will be significantly more affordable and hence will be more likely to be nationally accepted. Then, the challenge will be implementation. Our goal then becomes minimizing the inefficiencies in implementation present when new technologies clash with existing energy solutions. Rather, we aim to tap into markets which can benefit the most from new energy solutions.

In our findings, we discovered that Delaware, Washington DC, Arizona, Tennessee, and New York were the top five regions with the greatest opportunity for implementation of green technology.

State	Difference Score
DE	1.30094307
DC	1.10272713
AZ	1.04943958
TN	0.98551104
NY	0.97544572

Table 1: The states with the five greatest difference scores. These represent the states in which there exists the greatest market opportunity for implementation of green technologies.

5 Conclusion

In this analysis, we explored disparities between anticipated energy demands and supply through statistical analysis and prediction via machine learning. First, we analyzed air pollution data to understand the impact of unsustainable energy production practices. We then constructed a model for the market of electricity in order to identify the relationship between projected supply and projected demand and found that demand is projected to vastly outpace supply in several markets, making it essential that renewable energy to used to meet that demand to prevent environmental harm. Tying all these observations together, it becomes clear that while significant steps have been taken to reduce the impact of energy generation on the environment, this does create the potential for energy shortages in the future. Particularly, we could identify states where these differences are most significant. In theses states, our projections for demand will aid regulators in preventing shortages by investing in clean, renewable energy sources.

Our proposed solution to both the proliferation of air pollution as well as the the projected electricity shortage is one that has been discussed for a while but constantly relegated to research labs and the theoretical realm. Renewable energy must be the future in order for electricity supply to keep up with electricity demand. And that future needs to be now.

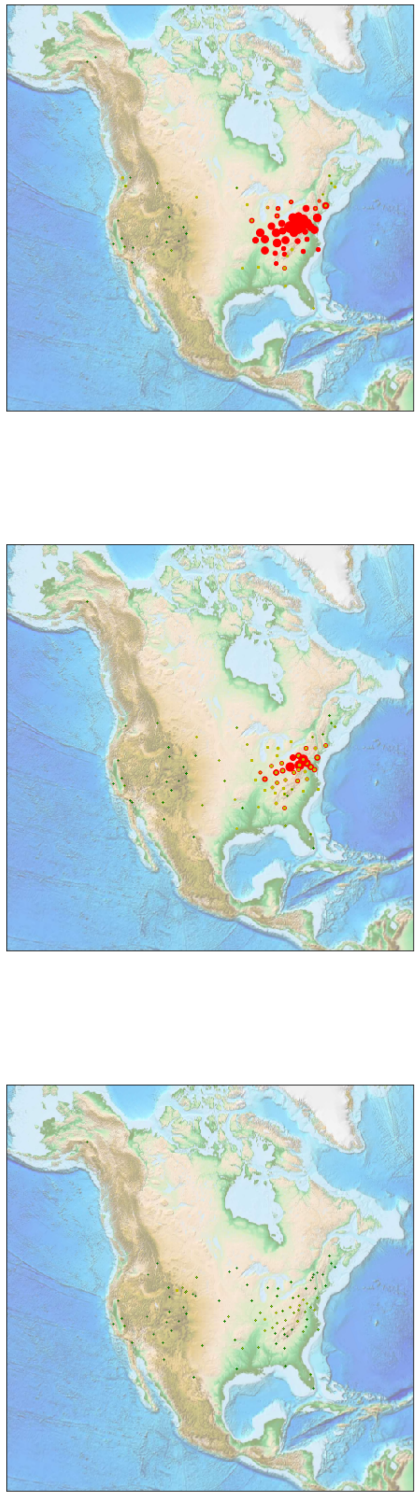

Figure 1: Air pollution in 2000, 2008, and 2017 from top to bottom

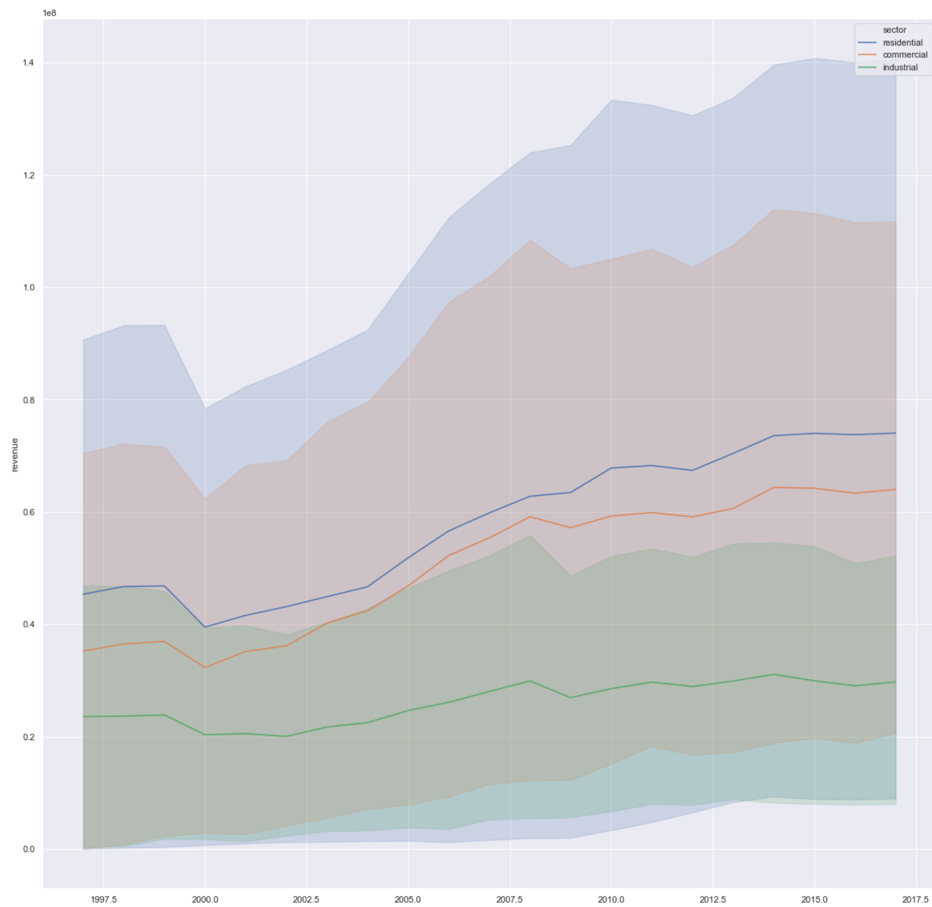

Figure 2: Revenues by energy consuming sector. The data shows that the revenues have stagnated over the past years in the industrial sector.

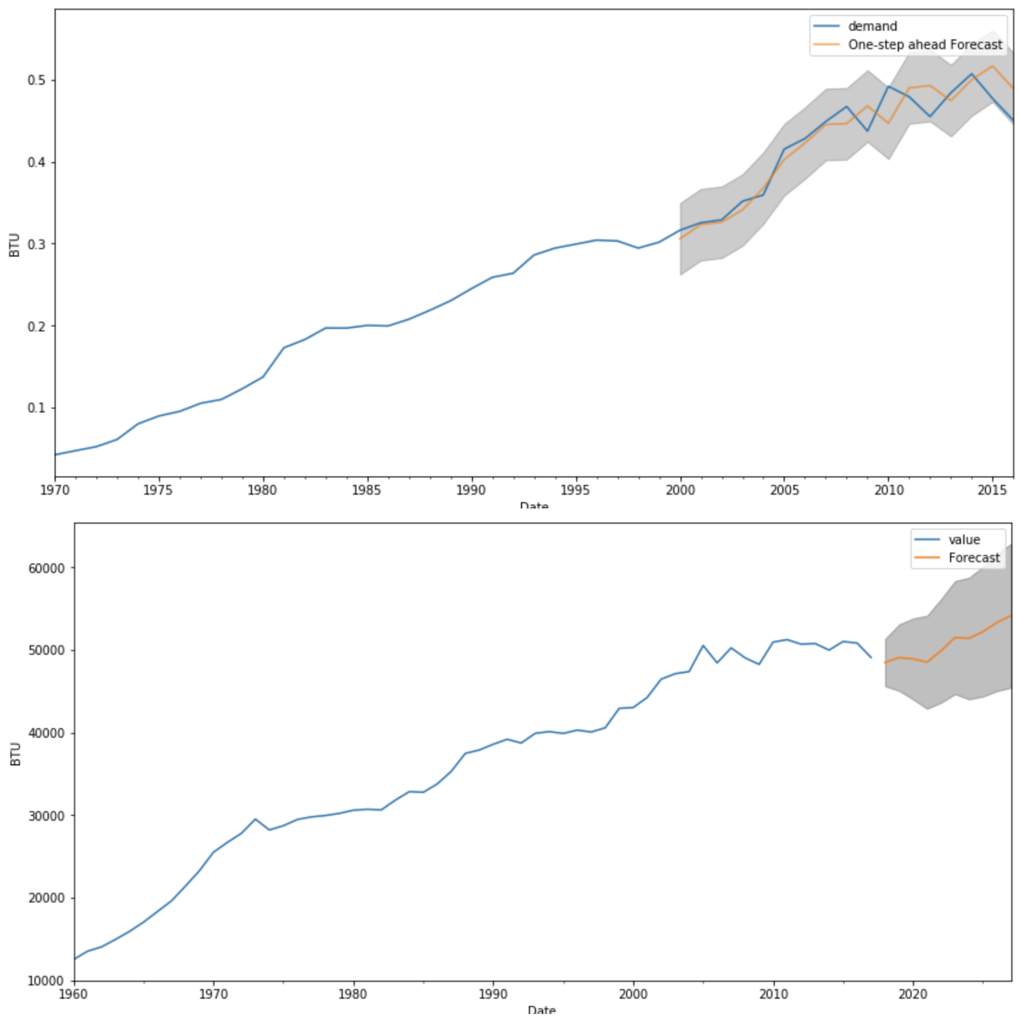

Figure 3: SARIMAX