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Electricity Demand Due to Policy Change in the U.K.

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Cover Page Footnote

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Introduction

The United Kingdom's Climate Change Act of 2008 was part of the Committee on Climate Change's (CCC) effort to reduce green house gases, with a long-term goal of an 80% cut in U.K. carbon emissions by the year 2050 an intermediate goal of 26%-34% by the year 2020. In efforts to see if this long term goal is on its way to be achieved, I take a look at consumer electricity demand as whole and compare how much demand has either increased, decreased, or stayed the same since the introduction of the Climate Change Act. The Climate Change Act of 2008 does not jump to any sorts of short-term monumental changes that would make a quick fix in the U.K. with regards to reducing emissions. It lays out a long term plan that does in fact set up check points and goals at certain points in time that lawmakers feel are necessary to clean up the atmosphere around them. In fact, after this was passed in 2008, the U.K. became the first country to set such a long-term plan for emissions reduction, beating such powerhouses like the United States and other large-scale economical countries to the punch. Intriguingly enough, the goals that were set by this act were very lofty, which led me to study if this piece of legislation has actually done anything to reduce emissions up until this point. The CCC, which became part two of the Act, was established shortly after the Act was passed. This committee has the power to aid the government with emissions projects and limits. They carry out what is probably the most important part of the Act's efforts, which is setting five-year carbon budgets. These budgets set a limit on the amount of GHG emissions during that fiver year span. These carbon budgets look to break down U.K. risks from climate change, look at initiatives that would address those risks, and encourage key companies and organizations within the energy sector to also be aware of the damage the excess emissions are doing to our atmosphere.

With regards to companies and organizations that contribute greatly to the production of non-renewable energy by way of fossil fuels, Nationalgrid is a United Kingdom based gas and electric company that supply's some 25 million customers with energy in the U.K. alone. They contribute greatly to the emissions problem that the Climate Change Act of 2008 is referring to. As mentioned above one of the steps that CCC is taking is to make companies like Nationalgrid aware of the damage they are doing to the environment. Nationalgrid's electricity generating facilities and generators use few renewable energy resources to provide their customers with the adequate amount of electricity that they demand. As you will see later in the paper, the countries renewable energy usage has increased but is still far from making much of difference when it comes to reducing emissions. Reaching out to companies who provide electricity and energy to consumers is one way to change current trends in emissions that are being released into the atmosphere. The Climate Change Act and the CCC are tackling the right types of issues that will eventually lead to a change in emissions, but their most important effort is reaching out to the companies that provide U.K. citizens with electricity. By reaching out to energy providers to reduce their emissions, this means that those companies need to make changes in their production and distribution of energy. In turn, consumers need to respond to utility company changes in distribution. It is almost like a domino effect. If you get the provider to reduce their emissions, you will most likely get the consumer to reduce theirs as well.

This all comes at a time where national awareness of pollution at any level is at an all time high. Environmentalist and governments are calling for major change to protect the environment and atmosphere around us. The production and usage of electricity go hand in hand as some of the largest contributors to GHG emissions. The demand for energy should be declining as a result of the initiatives, like the Climate Change Act, that are taking place in recent years. National demand for electricity is an important factor when it comes to the reduction of GHG emissions. Not only is it important to understand the electricity demand in the U.K, but also it is also important to know that there are major future implications with regards to global warming, climate change, and the usage of non-renewable energy sources. This study has national level implications as well as forward-looking global implications.

The primary question I seek to answer is: Has the Climate Change Act of 2008 had an effect on overall electricity demand in the U.K since it was enacted? It is important because the U.K. has poured many resources into this large-scale plan, and I'd like to find out if their money and time is being well spent. I hypothesize that this one policy change alone will have small, but positive effects on reducing electricity demand in the U.K. If my theory holds to be true then we can say that more efforts aimed at utility companies and reduction in emissions as a long term goal will only further the goal of releasing less GHG emissions into the atmosphere as a country. Since this was the first long term policy put in place, it serves as almost a trial as to what work in reducing electricity demand among consumers works and what does not. The trend in electricity demand before and after the Climate Change Act was put place will allow for a comparison to conclude if the Act actually had an effect on nation wide demand of electricity.

Literature Review

As for the Climate Change Act itself, there is almost no literature on the effects it has had on reducing emissions in the U.K. since it was implemented in 2008. Nationalgrid has little to no literature about their companies' customer demand and their own efforts to reduce emissions as part of social and governmental pressure. My narrow study of overall national electricity demand, predicted electricity demand from a leading U.K. utility company, and a singular policy put in place make for small results with no specific literature about my sources of data and study. What they do is paint bigger picture issues with regards to policy change, energy demand, and the role utilities and consumers play in reducing GHG emissions.

One of the only pieces of work found that relates directly to my work is (Watson, Majithia, 2005) "Analyzing the impact of weather variables on monthly electricity demand." Within the regression used in their paper, they use various weather variables along with GDP and population growth. I happen to use GDP and temperature as two of my main explanatory variables in the regressions that I run. Both of our papers find weather with regards to temperature a statistically significant variable when predicting electricity demand among consumers in the U.K. It makes sense that temperature would describe electricity demand, as extreme temperature months would be predicted to correlate with high electricity demand.

Fittingly, the paper on energy policy "Lessons for effective renewable electricity policy from Denmark, Germany, and the United Kingdom" (Lipp, 2007) offers a look at U.K. policy that pre-dates the Climate Change Act of 2008. This paper looks at policy change with regards to renewable energy initiatives in the years leading up to the specific policy change that I am studying. This paper starts in the 1990s and builds off of (Eichhammer 2001) that introduces when the U.K. first started to dabble into gas rather than coal. The Non-Fossil Fuel Obligation (NFFO) helped the renewable energy sector emerge. The emergence in the 1990s tailed off and the NFFO was never fully implemented as renewable energy support system. Throughout the early 2000s, no real effort was made to fully establish a set of renewable energy sites. This is why in 2008; the Climate Change Act was put in place as the first long-term policy effort to reduce emissions. The NFFO continued to go under a series of changes, which limited its resources and power (Parr, 2006). Ultimately, Lipp states that the U.K. was not as successful as Germany and Denmark were in acting on renewable energy initiatives during the 1990s and early 2000s. She says this was in part due to the governments focus on privatizing the electricity market instead of looking towards renewable energy efforts. This paper contradicts what effort the Climate Change Act promotes when talking about reducing emissions in the United Kingdom. Lipp does admit that climate change has recently (as of 2007) been a stimulant for pursuing renewable energy, but still says that the U.K. is behind on energy policy efforts with regard to reducing emissions and switching to more renewable energy sources.

The consumers, and more specifically households, are the main contributors to electricity demand and releasing GHG emissions into the atmosphere. If the U.K. government could get the majority of households to reduce their electricity and fossil fuel consumption as a whole then they would get much closer to reaching their lofty goal of emission reduction (Druckman, 2012). "Missing carbon reductions? Exploring rebound and backfire effects in UK households," outlines how the U.K. government has tried to influence household consumption of energy that contributes to GHG emissions. Druckman argues that the rebound effect negates some of the positive efforts that the government makes to reduce emissions within households because reducing consumption of energy only gives you more money to spend elsewhere to harm the environment. The Climate Change Act of 2008 aims more at regulating utility companies rather than going straight for reduction within households. This is alluded to as being a smarter plan because if energy is more renewable or there is less production, consumers do not have much to do with utilities changing their energy output.

Data

The ideal situation or test to be done to actually study the effects of policy change on electricity demand could span over numerous years using several policies that enact energy efficient and carbon reducing outcomes. This focuses on one major policy, the Climate Change Act of 2008 with regards to U.K. total energy demand, which excludes the generation through renewable energy sources to meet the consumer demand. The data includes 141 observations ranging from 2005-2016. Starting in April 2005 and ending in December 2016, each observation constitutes monthly electricity demand in megawatts for that given month. The data used is strictly time-series data. The data comes from Nationalgrid's data explorer, which can be found through their main website. The data set

they provide is made up of actual electricity demand, forecasted electricity demand, and production through use of renewable resources like wind power, hydropower, and solar power. To find total energy, I had to use an equation that took away renewable energy generation from the national electricity demand because I am trying to establish a casual effect between non-renewable electricity production and a policy that looks to clean up carbon emissions from those such sources. To help meet electricity demand in some months, additional generation through renewable sources were needed.

Total Demand = National Demand (U.K.) – Wind Generation – Solar Generation – Hydro Generation (1)

This ensures that my outcome variable (Total Demand) is made up of electricity produced from non-renewable resources that add to the continuing problem of GHG emissions in the U.K.

Figure 1.

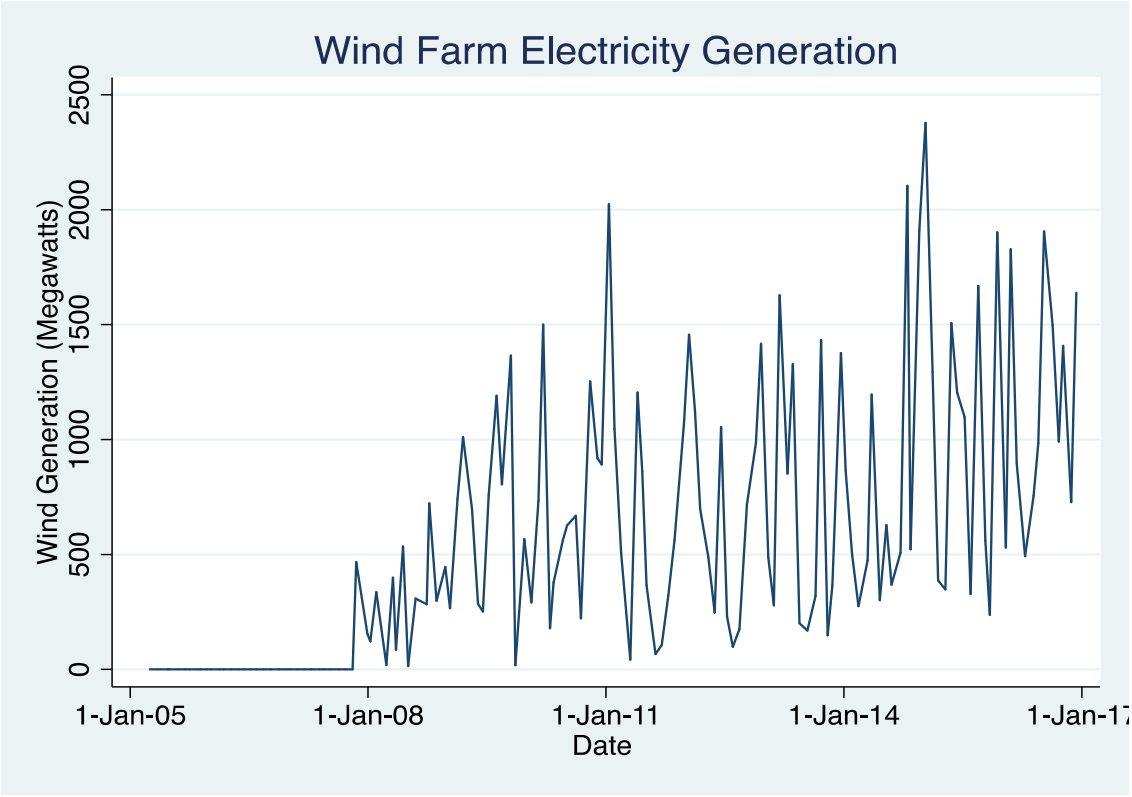
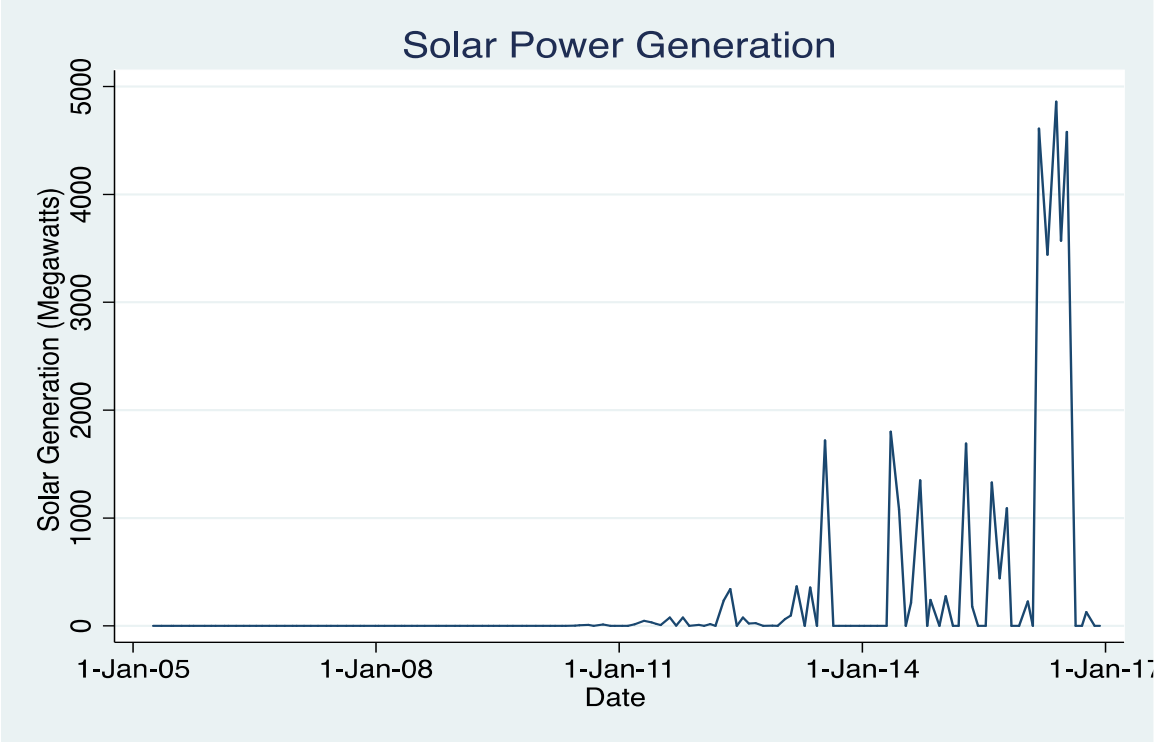


Figure 2.



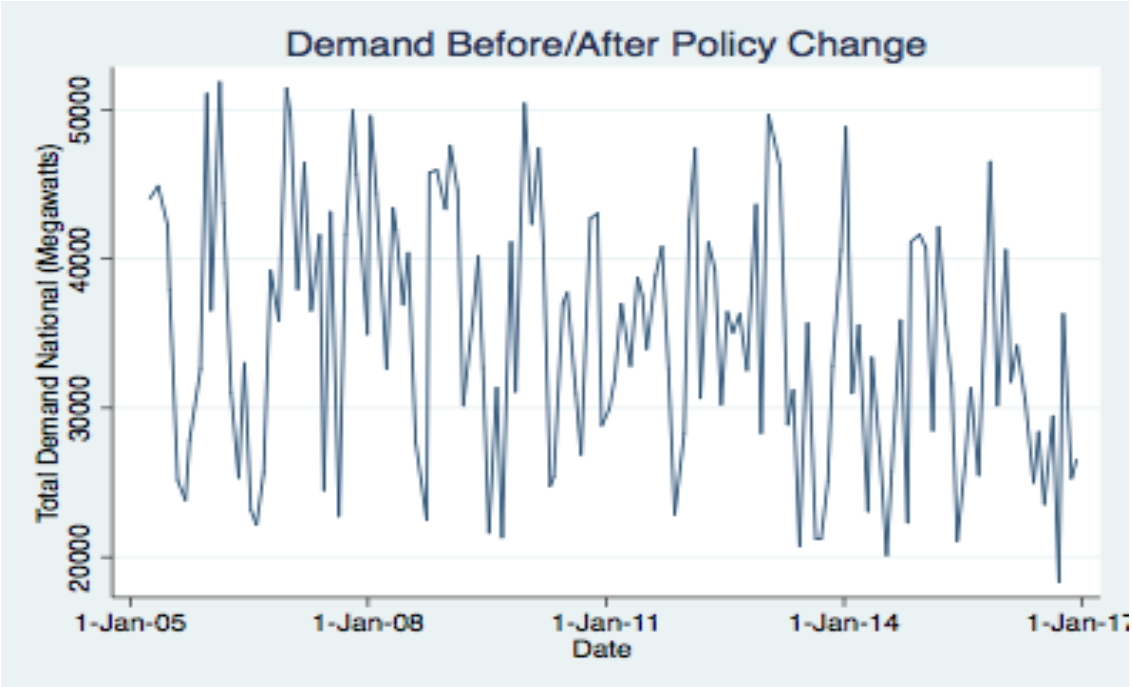
As you can see from figures 1 and 2 above, renewable energy sources make up a small amount of total energy demand. With regards to the policy put in place to reduce GHG emissions in 2008, you can see that both production of energy through wind and solar power have risen significantly since 2008. As for the policy overall, you would think that such a large scale change and numerous initiatives within the policy would promote and ultimately make renewable resources and more accepted option for utilities. But, as some of the previous literature has stated, the U.K. has had a tough time fully committing to cleaner production of energy, which most likely explains why the figures above do not show much progress.

Table 1.

Variable	Observations	Mean	Std. Dev.	Min	Max
National Demand	141	36180.68	8009.604	20616	51848
Total Demand	141	35003.77	8522.698	18324	51840
Wind	141	581.8227	574.54	0	2378
Solar	141	46.3475	835.8617	0	4860
Hydro	141	348.7376	556.24	0	1757
Income	141	454.5319	31.61771	386	509
Temperature	141	52.62411	9.096733	34	71
Consumption	12	1065863	37982.13	1019034	1147125
GDP	12	1641654	172439.7	1379457	1939637

The summary statistics for all variables used, whether that is in the regression or making variables to use in the regression, are listed above. Average monthly income (pounds), average household total consumption expenditure per year (pounds), and yearly GDP at market prices (trillions of pounds) were all obtained from The Office for National Statistics' "United Kingdom Economics Accounts time series data set." Average Temperature per month (degrees F) was obtained from Weather Underground's weather history page. The only shortcoming is the discrepancy between monthly and yearly data. Consumption expenditure and GDP were only able to obtained in yearly quantities, whereas all my other data is organized in monthly fashion.

Figure 3.



The peaks and troughs that happen before and after the Climate Change Act was enacted can be explained more by seasonal and temperature effects than policy implications. This is not seen in the regression that I used because I did not use seasonal fixed effects. The trend of this summary graph goes along with high and low temperature within the most extreme seasons that the U.K. experiences. Although we see a small reduction overall in the long-run since the policy has been put in place, which is just to the left of January 08, it is hard to conclude that this singular policy alone has had and will continue to have a significant effect on decreasing electricity demand, and in turn decreasing GHG emissions.

Empirics

To test whether or not the Climate Change Act of 2008 had an effect total electricity demand, it was necessary to create a dummy variable to establish two different periods. One period was for before the Act was put in place and the other was for after the Act was enacted. The simple OLS regression below shows the outcome and explanatory variables used.

$$Total\ Demand = \beta_0 + \beta_1 \cdot (After\ Policy) + \beta_2 \cdot (Income) + \beta_3 \cdot (Temperature) + \beta_4 \cdot (Consumption\ Expenditure) + \beta_5 \cdot (GDP) \quad (2)$$

Our outcome variable, *Total Demand,* is calculated from equation (1) listed previously in the paper. β_1 is the coefficient of the dummy variable for the divide between observations that happen before and after the Climate Change Act was put in place. β_2 is the coefficient on average monthly income per person in the U.K. over the selected time span. β_3 is the coefficient on average temperature per month in degrees Fahrenheit. β_4 and β_5 are coefficients on yearly average total consumption expenditures per household and yearly GDP at market prices.

Table 2.

	Model 1
After Policy	-0.028
	0.01
Income	137.003
	(725.85)
Temperature	-775.203*
	(250.63)
Consumption	0.387*
	(0.13)
GDP	-0.101*
	(0.04)
_cons	-222138.353
	(293373.05)

R-squared 0.589
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*p<0.05, **p<0.01, ***p<0.001

From Table 2 it is evident that temperature, GDP, and consumption expenditures are all significant explanatory variables. What is most evident is the large negative correlation temperatures coefficient has with total demand and how income is not significant at all. If I were to guess I would have hypothesized that as temperature increased then the total national demand with respect to non-renewable energy sources would go up, not significantly down. I also would have guessed that average monthly income would be one of the most significant variables with respects to total demand. The tell tale story that my regression shows is that it is not so much the policy that changes electricity demand, especially when dealing with only one policy change. The adjusted r-squared of the model is higher than expected, with almost 59% of the variance in the data being explained. Although, this may be misleading because there are many other variables and biases that go into total electricity demand. It s hard to conclude that my regression truly did its job in explaining if the Climate Change Act of 2008 is making progress in cleaning up emissions by reducing electricity demand.

Conclusion

Much of the work you see here revolves around consumer energy demand. As you can see the policy that I chose to look at had little change after it was implemented. One major flaw in this study is that it does not take into consideration more of the production side of utility companies, because they are the ones who are effected more by changes in policy. It was good to see how electricity demand in the U.K. changed small amounts after the Climate Change Act was put in place, but studying multiple utility companies production of energy through whatever sources they are using could be a potential extension of what I have looked at. Utilities are playing the middleman between consumers and the government making policy changes. Utility companies, like Nationalgrid, are affected more by policy change in their processes of creating energy than consumers are in their process of consuming it. With this being said it would pay dividends to look at an abundance of U.K. utility companies and how their energy production responds to the Climate Change Act or something similar. Also, since 2008 many other countries have adopted to similar plans to reduce emissions. It would be interesting to see comparisons between countries such as the U.K. and U.S. and which country can get their consumers to respond more actively.

As previous works from (Weber Shah 2011, Herring Sorrell 2009, and Bessec Fouquau 2008) all suggest the temperature has a large effect on consumer energy demand. As temperature and seasonal effects on electricity and energy demand are evident from previously literature, I decided to branch out to see if a certain policy put in place under the U.K. government stood a chance at effecting electricity demand, and in turn helped reduce emissions. The Climate Change Act is aimed at a long-term goal. Almost ten years have passed since it was put in place and my study proves that though there is some small decrease in total energy demand, the Act itself has not proven to be

on pace to reaching its long term goals. More so, I can conclude that any individual policy put in place will likely not have large effects on decreasing demand and emissions. It's going to take a large-scale amount work with regulations set on utility companies like Nationalgrid, projects on renewable energy sources, and consumer awareness efforts. All in all there needs to be a larger and more diverse effort made by the U.K. to reach lofty goals like the ones that are set in the Climate Change Act.

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