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# *THE IMPACT OF CLIMATE CHANGE ON THE SUPPLY AND DEMAND FOR ELECTRIC POWER AND WHOLESALE PRICES FOR ELECTRICITY IN GERMANY*

## Overview

In the aftermath of the liberalization of the electricity market in the European Union, various factors have affected electricity prices. Recently, with the promotion of electricity generated by various sources of renewable energy, such as photovoltaics (PV) and wind power, it has been found the generation of electricity by renewable energy sources negatively affects electricity prices (i.e., reducing electricity prices), which is often referred to as the merit order effect. Some previous studies have already found the merit order effect in the wholesale market in European countries (e.g., Cludius et al. (2014)). However, these studies do not reveal the weather condition effect on the wholesale price of electricity when considering merit order effect. Weather conditions not only have a strong effect on solar PV and wind power generation, they affect electricity demand as well (e.g., the demand for electricity increases during hot summer months). Therefore, there are complicated relationships among electricity prices, electricity demand, renewable power generation, and weather conditions. As climate change produces more serious climatic conditions, understanding the influence of the weather on electricity markets will become even more important. Thus, this study aims to estimate the relationship among electricity prices, electricity demand, renewable power generation, and weather conditions focusing on the German electricity spot market.

## Methods

To estimate the relationship among electricity prices, renewable-energy power generation (Solar PV and wind) and meteorological conditions, we applied structure equation modelling. This estimation model is deemed appropriate given the complexity of the relationships among the variables. In particular, solar activity affects both the demand and supply side of electricity. Based on the discussion of previous studies and the correlation coefficient between each of the variables, we set up the structural model. Figure 1 shows the model adopted in this study. As shown in the figure, the spot market price of electricity is the dependent variable, while load, solar PV and wind power generation, and weather conditions (temperature, radiation, and wind speed) are independent variables. We also included dummy variables for hours, days of the week, months, and years as independent variables. These data are in time series from 19 July, 2010 to 28, December, 2016. The resolution of our dataset is 3 hours to be consistent with that of the data for weather conditions.

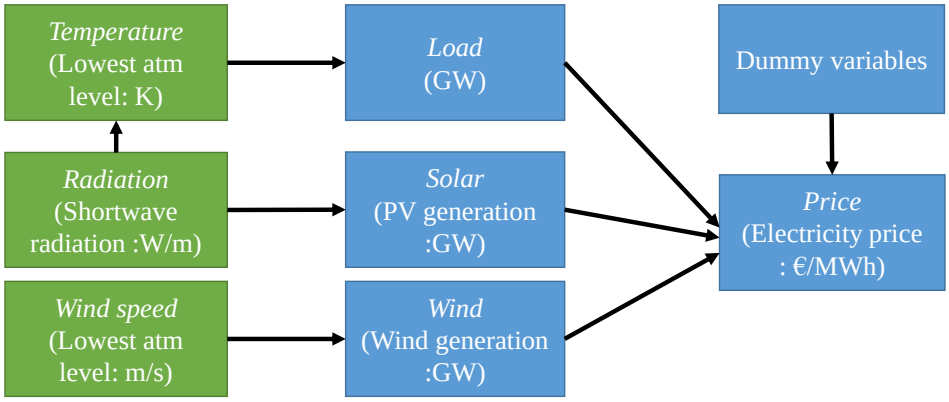


Fig. 1 Model assumed in this study.

We obtained the data from the following sources. Electricity prices were taken from the European Power Exchange (EPEX), the total load was taken from the European Network of Transmission System Operators for Electricity (ENTSO-E), the electricity generated by solar and wind was taken from the European Energy Exchange

(EEX), and the weather conditions (temperature, radiation, and wind speed) were taken from the Research Data Archive (the WFDEI Meteorological Forcing Data).

## Results

Table 1 shows the estimation results based on the model shown in Fig. 1. First, we focus on the direct factors for electricity prices (*Load*, *Solar*, and *Wind*). Our estimation result shows *Load* is positive and statistically significant to *Price*. This means increases in total demand exert upward pressure on the wholesale electricity price. However, *Solar* and *Wind* exert downward pressure and are statistically significant to *Price*. These results are in line with the findings of previous studies. In short, increasing the amount of renewable energy decreases wholesale electricity prices.

Second, we need to consider the effect of weather conditions, in particular, solar radiation. Our estimation results show that *Radiation* is positive and statistically significant to *Temperature* and *Solar*. However, *Temperature* negatively affects *Load*. In Germany, the peak of electricity demand comes during the winter season. Therefore, lower temperatures increase the demand for electricity. On the other hand, our result suggests that *Radiation* is the increasing factor of *Solar*.

Finally, rises in *Radiation* decrease the demand for electricity and increase the supply from *Solar*. These results indicate that if temperature and solar radiation increase in the near future due to climate change, the impact of weather conditions may reduce wholesale electricity prices. In particular, our estimation shows that the effect of temperature is large. The indirect effect of the *Temperature* on electricity prices is -0.0586. On the other hand, the merit order effect of solar PV is 0.0011. Thus, the influence of temperature and solar radiation on change in demand for electricity is larger than the change in supply under such conditions.

Table 1 Estimation results of each dependent variables

| Dependent variables | Independent variables | Coefficients | SD |
|---|---|---|---|
| *Price* | *Load* | 0.0011*** | 0.0000 |
| | *Solar* | -0.0011*** | 0.0000 |
| | *Wind* | -0.0011*** | 0.0000 |
| *Load* | *Temperature* | -54.21*** | 10.33 |
| *Temperature* | *Radiation* | 0.016*** | 0.0000 |
| *Solar* | *Radiation* | 17.68*** | 0.20 |
| *Wind* | *Wind speed* | 3481.11*** | 21.38 |

Note) *Significant at the 10% level, **Significant at the 5% level, ***Significant at the 1% level.

## Conclusions

In this study, we estimated the impact of weather conditions on wholesale electricity prices. Our results showed that the solar radiation affects both the demand and supply of electricity. In particular, temperature has a large impact on the demand for electricity. In Germany, electricity is largely used during the winter season. Therefore, electricity prices will not be high if increases in temperature occur due to climate change. However, our results suggest that electricity prices of the southern areas of the world may increase as a result of increases in temperature brought about by climate change.

Some previous studies demonstrated changes in the supply of electricity caused by climate change. For example, Bartons and Chhester (2015) analyzed the effect of draught on the electricity supply from renewable energy in the United States. They found that climate change may reduce average summertime generating capacity by 1.1–3.0%, with reductions of up to 7.2–8.8% under a ten-year drought. This evidence means that policymakers need to be more aware of the effect of long-run weather condition changes in estimating future electricity supply and demand. We also found that weather conditions affect electricity supply from solar PV and wind power generation. Additionally, our results indicate changes in demand under variable weather conditions. These results are important to understand the comprehensive effect of weather and climate change on electricity supply and demand.

## References

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