Correlation Analysis of Renewable Energy Sources for Future Power Preparation in Jeju

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Abstract. In order to prepare for the energy crisis, the exploitation of renewable energy sources such as wind, solar, and water is now in progress. In addition, researchers have developed various kinds of products that use electricity instead of oil. Electric vehicles are one of good examples. Recently, as the consumption of electricity has increased, there is much attention towards electric power generation by using the renewable energy sources. However, unlike the existing energy sources, they are intermittent and uncontrollable. Hence, this research examines the correlation between the renewable energy sources, wind and sunlight, based on time and region to predict the renewable energy sources more accurately and to acquire power stably from the renewable energy sources.

Keywords: Renewable Energy, Smart Grid, Wind Power, Solar Power, Correlation.

1 Introduction

In order to prepare for the exhaustion of oil, many companies and organizations have addressed the development of alternative energy and proposed new products using the alternative energy. One of the products is electric vehicles. For instance, Jeju City became a smart grid test bed 3 years ago. Since then, a lot of research works related to electric vehicles have been performed, and in order to charge all the electric vehicles, many researchers have developed the methods to guarantee sufficient power supply. The power support from the renewable energy sources is a good solution for smart grid. In fact, since the wind potential of Jeju Island is great, many research works mainly focused on wind energy as renewable energy sources [1][2]. Thus, there has been a lot of research about the interconnection between the renewable energy and the smart grid [3][4].

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However, the prediction of power generation from the renewable energy sources is difficult because the weather factors are fluctuating. Thus, we cannot figure out how much the amount of the renewable energy would be generated [5]. One of the models for forecasting power generation is the spatial correlation model. However, besides the spatial factor, time also plays an important role in finding the correlation among the weather factors. The weather factors such as wind, rainfall, and sunlight are correlated with each other according to seasons. If we examine the correlation among the weather factors according to time and location, then we can predict power generation more accurately. Accurate prediction about power generation makes an efficient policy for charging the electric vehicles in smart grid cities.

In the research [6], solar and wind power were analyzed separately in terms of regional correlation. The research only focused on the positive correlation between regions. While the positive correlation tells us the similarity between regions, the negative correlation tells us the difference between regions. The negative correlation is also meaningful to predict the power generation. Thus, we analyze the wind speed and the amount of sunlight on Jeju Island by using the correlation analysis and ANOVA (analysis of variance) to prepare a basis for predicting power generation in this paper. We consider the weather data for 4 regions: Jejusi, Seogwipo, Seongsan, and Gosan. In order to accomplish this research, we use the data collected in Korea Meteorological Administration from 2000 to 2010 [7].

2 Background

Since this research is interested in the combination of wind and solar energy generation mechanism, we firstly examine the previous research related to the wind/solar power plant status in Korea. There was a study on examining two types of relationships: peak load- sunlight power and peak load-wind power [6]. According to [6], the wind power has no correlation with the peak load, but the solar power has a little correlation with the peak load in South Korea. It means that the energy source does not contribute greatly to preventing the shortage of electricity during peak load time. In addition, the research analyzed the positivity of the correlation among regions to check if the regions had similar wind and solar power patterns. Similarity means that when a region has low renewable energy power, the other region also has the low renewable energy power. Thus, the renewable energy power is predictable, but cannot cover the shortage of electricity at that moment. In this case, we have to prepare another source of energy for the stable power generation. If the regions have no correlation, then we cannot apply the same policy to this case. The correlation can determine the modeling method to generate renewable energy power. However, the research has a few limitations because it only considered the positive correlation in the wind and the solar respectively. Similarity is important, but difference is also important when we model the renewable energy sources. Negative correlation between two factors represents the differences between sources, and it helps to complement the sources with each other.

3 Correlation Analysis and Analysis of Variance

In this Section, we present the correlations in the wind speed and the amount of the sunlight among regions in Jeju Island. For the wind speed, the correlation coefficients of Jejusi and Seongsan, Jejusi and Gosan, Seogwipo and Seongsan, and Seongsan and Gosan were .74, .96, .43, and .78. They were all statistically significant. For the sunlight, the correlation coefficients for all the pairs of regions were statistically significant. The values were ranged from .53 (Jejusi-Seogwipo) to .92 (Jejusi-Gosan). However, the correlation coefficient of Seogwipo (south) and Jejusi (north)/Gosan (west) were .099 and .035 respectively. These were not statistically significant. It means that the northwesterly wind dominates Jeju area, but due to Halla Mountain, Seogwipo is not affected from the wind direction [8]. We should take into account the difference between the north and the south as well as the difference between the east and the west as described in [6].

Next, we present the meanings of the values made by subtracting the monthly mean of the sunlight from the monthly mean of the wind speed in the 4 regions. According to Fig. 1, Jeju and Gosan had greater values in wind than in sunlight during winter. However, other region usually had negative values from January to November. It means that during winter season, wind power is more valuable to generate power in Jeju and Gosan. In Seogwipo and Seongsan, the sunlight is more valuable than wind during spring and summer. From the graphs, we knew that when the value is greater than 0 (zero), we can expect more power from wind than from solar. On the contrary, for the negative values, we can expect more power from solar.

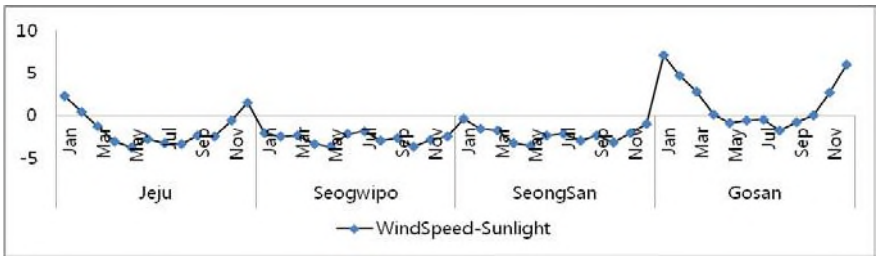

Fig. 1. Differences between the Monthly Mean of Wind Speed and Sunlight

Finally, in order to examine how much the values are exactly different, we performed the analysis of variation with post-hoc analysis. For simplicity, we divide months into 4 seasons. For all pairs of the regions and the seasons, the wind speed was significantly different. The exact differences between seasons were ranged from -1.66 (summer-winter) to .72 (spring-summer). The exact differences between regions were ranged from -4.1 (Seogwipo-Gosan) to .61 (Jejusi-Seogwipo). And, the season and the region explained the wind speed about 54.9%. On the other hand, the amounts of the sunlight were almost significantly different among seasons and regions. The exact differences between seasons were ranged from -.08 (summer- autumn) to 1.67 (autumn-winter). The exact differences between regions were ranged from -.55 (Jejusi-Seogwipo) to .24 (Seogwipo-Seongsan). The season and the region explained the amount of the sunlight about 93.8%. The difference between spring and winter

was the biggest. The difference between Jejusi (north) and Seogwipo (south) was the biggest.

4 Conclusions

From the results, we knew that the wind speed and the amount of sunlight are positively correlated between months and between regions respectively. For the wind speed, the difference between summer and winter was the greatest and the difference between Seogwipo and Gosan was the greatest. For the amount of the sunlight, the difference between spring and winter was the biggest and the difference between Jejusi and Seogwipo was the biggest. We cannot apply the same prediction or modeling policies to the all regions and to all seasons. Even though the regions had the similar renewable energy source patterns, the mean values for the renewable energy sources were different statistically. In addition, the previous research works have performed analysis only by regions. However, if we consider the interaction between time and location when we establish a power generation model, we can increase accuracy of the model. Also, we should consider the difference between regions and seasons when we model the power generation in the near future.

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