One Day Ahead Forecasting of Generating Power for Photovoltaic Power System

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***Abstract*—Photovoltaic power generation is affected much by weather and temperature, so the amount of power generation is not constant and there are many difficulties in predicting. Thus, the accurate prediction of the photovoltaic power due to climate change is critical to stable electricity supply. In this paper, in order to create a power generation forecast model, the data, such as power generation, temperature, Daily Mean Cloud Amount (DMCA) data has been collected from April 2016 to September 2016. Using the neural network, the peak solar irradiation forecasting model was created, solar irradiation was calculated from the peak solar irradiation predicted, and finally the model to predict power generation was made. In this paper, the peak solar irradiation is predicted using the maximum temperature and the peak solar irradiation data, and ultimately the solar power generation is predicted through the predicted peak solar irradiation.**

Keywords - Solar irradiation; Neural network; Photovoltaic; Forecasting model.

I. INTRODUCTION

Recently, concern for the development of alternative energy resources has been growing as the energy problem gets worse worldwide. Accordingly, the importance of renewable energy is emerging and the proportion of photovoltaic (PV) power system in the various renewable energy sources is increasing. Nowadays the use of the distributed power generating systems, especially those using PV, is increasing due to the maintenance free, long lasting, and environment friendly nature of PV [1]. Accurate prediction of PV generation accompanying climate change is important for stable supply of electric power, since PV generation is most sensitive to climate change among renewable energy sources.

In this paper, the data measured by the energy Management System (EMS) built in the smart grid system is utilized, and the prediction of the PV power generation aims at the efficient energy management of the EMS. In Section II, past temperature data and solar irradiation data were collected and analyzed, and the maximum temperature and the peak solar irradiation were classified. In Section III, peak solar irradiation was predicted using the Neural Network (NN). Utilizing the predicted peak solar irradiation, finally, the amount of PV power generation was predicted.

II. ANALYSIS OF EXPERIMENTAL DATA

First of all, before starting the experiment, temperature data, solar irradiation data and DMCA data from April 2016 to September 2016 were collected and analyzed. Daily maximum temperature and daily peak solar irradiation data were calculated and classified. Temperature and DMCA data were collected from the Meteorological Agency and solar irradiation data was collected through its own EMS. Figure 1 shows the experimental data of hourly solar irradiation during April - September 2016. The DMCA data, peak irradiation data, and maximum temperature data were normalized, and the correlation of the normalized data was analyzed. Figure 2 shows the relationship between peak solar irradiation and DMCA data. As a result of analyzing the normalized DMCA and normalized maximum solar irradiation, it can be confirmed that nonlinear inverse proportional curves are created in which the solar irradiation becomes smaller and smaller as the DMCA is larger. Here, the normalized DMCA value 0 means sunny, 1 means very cloudy. Figure 3 shows relationship between peak solar irradiation and maximum temperature. The maximum temperature and the peak solar irradiation are also normalized and then analyzed. As a result, as for the maximum temperature and peak solar irradiation, a nonlinear proportional curve is created as shown in Figure 3 and was predicted. Using the analyzed data, a peak solar irradiation prediction model is created, and the peak solar irradiation is predicted by this forecasting model. Then, the daily solar irradiation was predicted from the predicted peak solar irradiation, and finally the amount of PV power generation.

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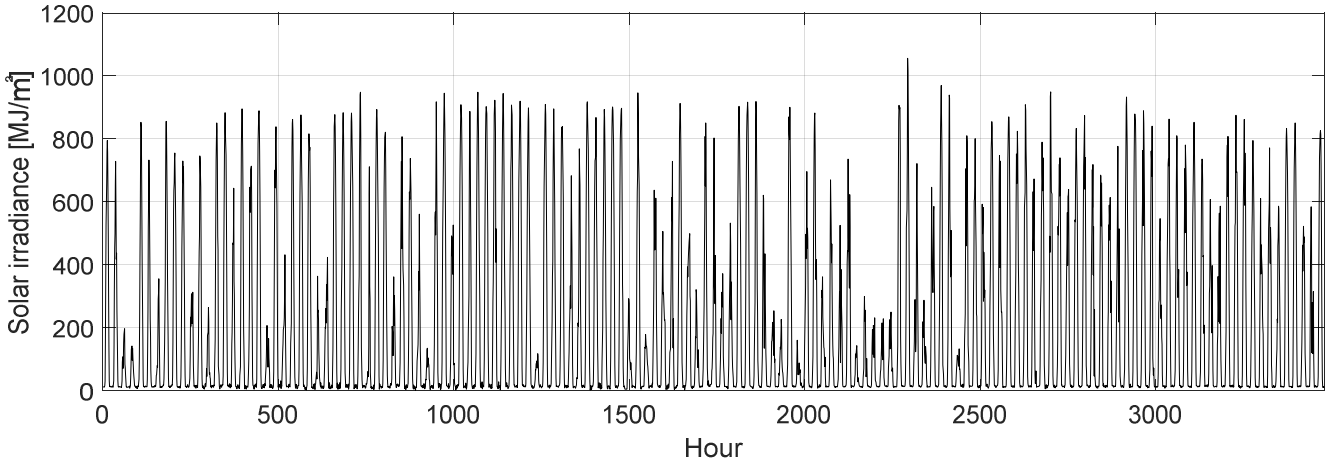

Figure 1. Experimental data of hourly solar irradiation

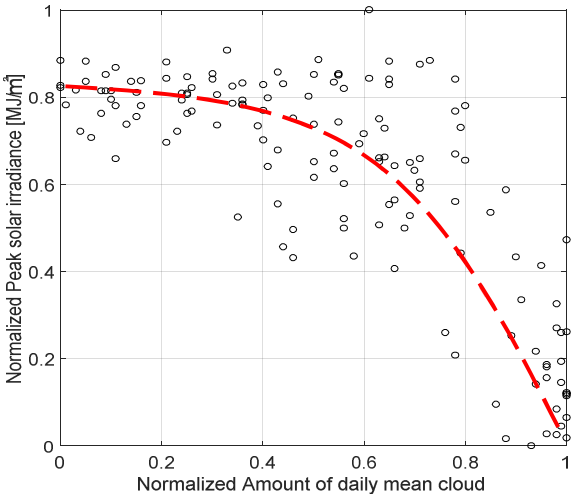

Figure 2. Relationship between peak solar irradiation and daily mean cloud amount data

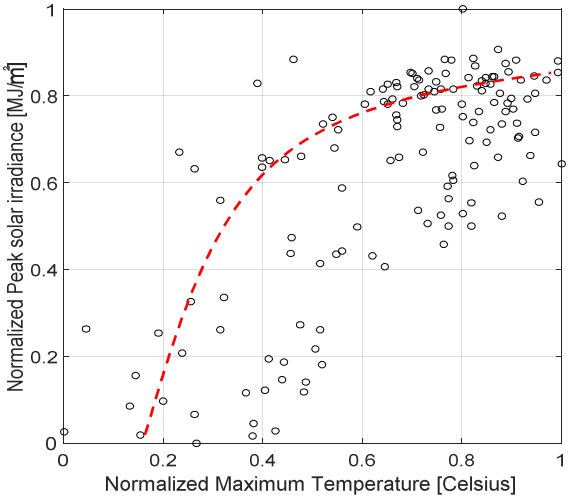

Figure 3. Relationship between peak solar irradiation and maximum

III. SIMULATION

In this paper, simulation to predict one day ahead generating power output for PV system was executed for efficient energy management of EMS. In order to compare the actual generating power amount of the PV power generation system with the predicted PV output value of the program, the research institution of City C in Korea is selected and installed, and the capacity of the PV system is 50 kW.

Single layer feedforward NN [2] was used for peak solar radiation forecasting algorithm. NN is very effective in prediction and is used in various fields, and the model output value calculated by input and the desired output value update the connection weight to minimize the error. The input layer receives as parameters the peak solar irradiation, the maximum temperature and the DMCA, while the output layer gives as parameters the peak solar irradiation at the next day [3]. Prior to performing the algorithm, DMCA data, maximum temperature data, peak solar radiation amount data as the input data are normalized between 0 and 1. The simulation was carried out assuming that tomorrow's cloud data and maximum temperature data are known through the Meteorological Agency forecasts. Peak solar irradiation was predicted by using single layer feedforward NN with maximum temperature, peak solar irradiation, DMCA as input data. The generating power for PV system was calculated by using the least squares method, which is a method for minimizing the sum of squares of distances between actual values and values predicted by trend lines.

IV. FORECASTING RESULT OF POWER OUTPUT

Figure 4 shows the forecasting of daily peak solar irradiation and the solar irradiation. The solar irradiation that has not been measured was excluded from the simulation in September 2016. Figure 5 shows the chart of predicted solar irradiation for sunny day and Figure 6 shows the chart of predicted solar irradiation for cloudy day.

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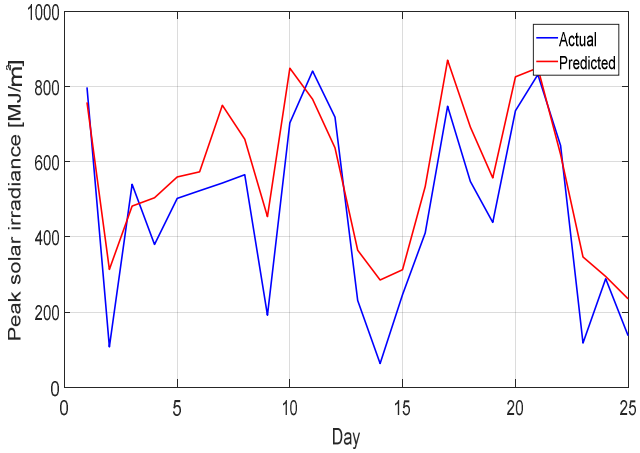

Figure 4. Forecasting of daily peak solar irradiation in September 2016

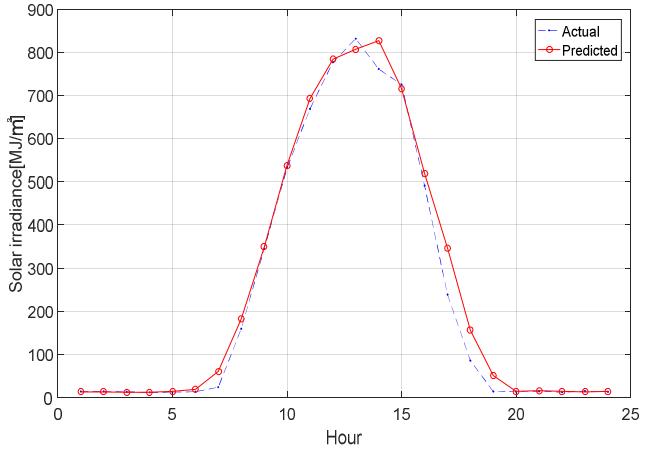

Figure 5. Forecasting of solar irradiation for sunny day

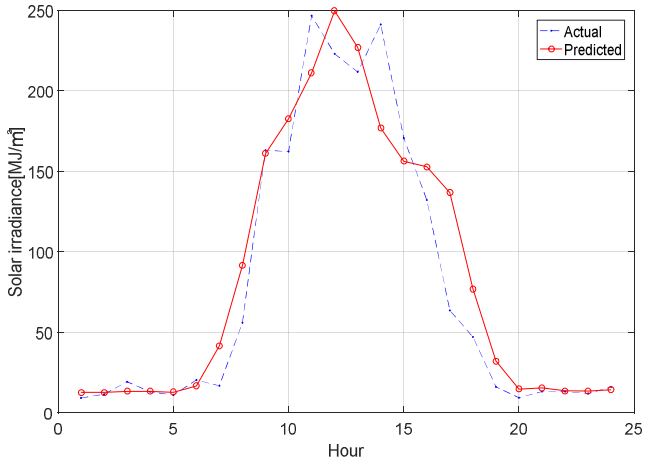

Figure 6. Forecasting of solar irradiation for cloudy day

TABLE I. DAILY SOLAR IRRADIANCE

	Cloudy day(9/18)		Sunny day(9/24)	
Hour	Actual data [MJ/m^2]	Predicted data [MJ/m^2]	Actual data [MJ/m^2]	Predicted data [MJ/m^2]
1	9.3	12.8	14.3	13.1
2	11.6	12.8	14.7	13.1
3	19.4	13.5	13.4	12.3
4	13.2	13.5	12.4	12.3
5	11.1	12.9	12.7	14.4
6	20.5	16.8	13.6	19.3
7	16.9	41.8	24.2	60.4
8	56.0	91.7	159.6	182.3
9	163.1	161.1	344.4	349.0
10	162.3	182.8	532.4	538.1
11	246.7	211.2	668.8	692.6
12	223.0	249.7	776.9	783.8
13	221.8	227.0	831.4	806.7
14	241.2	176.9	761.1	827.2
15	170.7	156.3	725.1	715.9
16	132.2	152.8	491.2	519.1
17	63.7	136.7	238.6	346.2
18	47.2	77.1	85.7	156.3
19	16.2	32.3	14.4	50.6
20	9.4	14.8	13.6	14.3
21	13.3	15.6	14.9	16.1
22	13.3	13.7	12.7	14.7
23	12.1	13.5	15.1	13.3
24	16.1	14.5	13.5	14.3

Table 1 shows a comparison of Actual solar irradiance data and predicted solar irradiance data. Through Table 1, it is possible to confirm that predicted solar irradiance and the accuracy of the prediction were verified with Mean Absolute Percentage Error (MAPE). As a result of obtaining the MAPE of the forecasted solar irradiation from 10 a.m. to 4 p.m. when the amount of sunlight increased, MAPE was 3.2% on a sunny day and MAPE was 12.3% on a cloudy day. It is difficult to predict because the shape, quantity and weight of the cloud cannot be confirmed and clouds are a major contributor to the amount of solar radiation. Through Figure 5 and Figure 6, it can be confirmed that the hourly solar irradiation on a sunny day is comparatively better than the day with clouds. Figure 7 shows a comparison between actual data and predicted data. Figure 7(a) shows forecasting of hourly solar irradiation and Figure 7(b) show forecasting of hourly generating power output for PV system in September in 2016.

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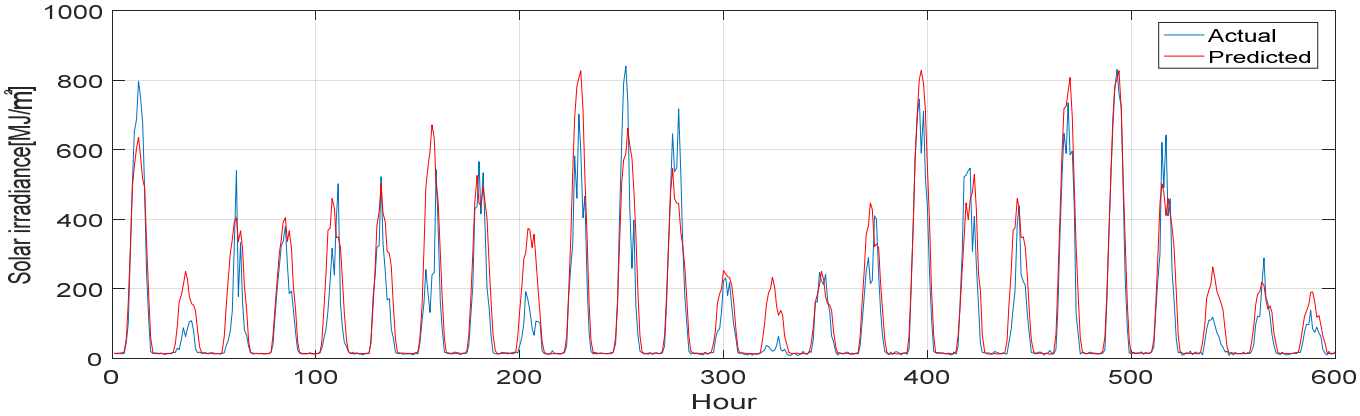
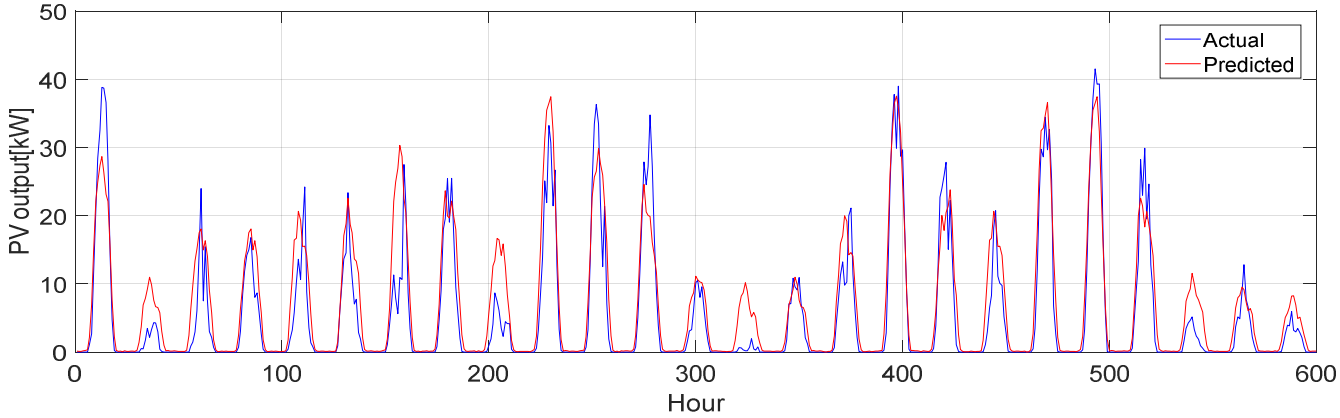


(a) Forecasting of hourly solar irradiation



(b) Forecasting of hourly generating power output for PV system

Figure 7. Comparison of Actual data and Predicted data

It can be confirmed by seeing Figure 7 that the hourly solar irradiation curve pattern and the hourly generating power output of for PV system curve pattern are similar.

V. CONCLUSION

This study predicted PV power generation to make a plan for operating ESS efficiently. In Section II, temperature, solar irradiation and DMCA data from April 2016 to September 2016 were collected and analyzed. In Section III, by using NN, the peak solar irradiation amount was predicted, and one day ahead daily solar irradiation amount was also predicted using the predicted peak solar irradiation amount. Then, PV power generation amount was predicted using the predicted daily solar irradiation amount. Experimental comparison between generating power output forecasted through experiments and actual PV output data and predicted solar irradiation amount and actual solar irradiation data were compared. The proposed method shows that the predicted PV values and the actual PV values are displayed in a similar curve pattern. The forecast of PV on a sunny day improved relatively, but in the case of many clouds, the accuracy of the forecast of PV decreased due to the amount of clouds and various factors. For follow-up research, solar altitude data will be added to the input data of the solar prediction model.

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