Second by Second Prediction of Solar Power Generation Based on Cloud Shadow Behavior Estimation near a Power Station

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Abstract. Photovoltaic (PV) power generation has a particular problem for grid cooperation in that output can fluctuate due to the shadows created by clouds. If we can grasp the behavior of cloud shadows beforehand, then it may be possible to forecast output fluctuations. In this study, we want to prove if it is possible to calculate power output variation from the accumulated cloud shadow data. Cloud shadow behavior was measured from the ground by photodiodes (PDs) and the cloud shadow vector was calculated from the position and time difference. The time from the calculated cloud shadow vector to the arrival of the cloud shadow and the power generation output was calculated and compared with the actual solar power generation output. Thus, we confirmed that we can predict power generation output from a high correlation of two outputs. We found that prediction is possible, with high precision, at a short distance.

INTRODUCTION

In recent years, numerous solar power generation facilities have been constructed in Japan. Fig. 1 shows an installation map of the Aichi Prefecture Mikawa District where Toyohashi University of Technology (TUT) is located. This figure represents data from November 2015 which shows that there are many medium-scale (100 kW - 2 MW) and large-scale (More than 2 MW) solar power generation facilities. In this case, the figure excludes small-scale sites. PV power generation output is dependent on the amount of solar irradiance. On a sunny day the amount of solar irradiance is stable, but on a cloudy or rainy day, influenced by clouds, the amount of solar irradiance is unstable resulting in output fluctuations [1]. Solar fluctuations due to clouds can occur between a few seconds and a number of minutes [2, 3, 4]. Variation in solar radiation caused by passing through cloud shadows has been previously studied [5, 6, 7, 8]. The operation of a PV system in a partially cloudy state has also been studied [9, 10, 11, 12, 13, 14, 15, 16]. In addition, output fluctuation when a cloud shadow passes over a PV system has been studied [17, 18, 19, 20, 21]. A sharp increase in PV generation causes various problems such as reversed power flow and reactive power in the power system [22]. Knowing the movement of the cloud shadow is important for short term power generation output prediction [23, 24]. Satellite observation is suitable for observation of wide area clouds in understanding the motion of cloud shadows [25, 26, 27, 28]. However, satellite observation for local and short-time prediction is difficult.

For local measurement, a research has been undertaken to detect cloud shadow speed by using two PDs on the ground [29] and there are studies to trace the minimum value of the entire PD array, taking the rectangular cloud into account and deriving the velocity vector from the irradiation data [30]. In addition, a method of measuring the behavior of cloud shadows with eight phototransistors arranged in a semicircle shape has been proposed. In order to facilitate the calculation, a method of determining the speed and direction of shadow movement from the time difference between a set of three PDs were presented, and the speed and direction of the cloud shadow were calculated [31].

In this research, to calculate with a higher accuracy than that obtained by using three PDs, we increased the number of PDs to four and set the three sets of PDs to four pairs. Furthermore, the parameter of the cloud shadow was obtained from the simplified calculation formula rather than the calculation method used previously, and the power generation

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