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DAILY INSOLATION FORECASTING USING A MULTI-STAGE NEURAL NETWORK

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Abstract—So far a single-stage neural network has been proposed to forecast the insolation of the next day. The mean error of the forecast insolation by the single-stage neural network is about 30%. In this paper, a multi-stage neural network is developed for further reduction of the mean error. A first-stage neural network forecasts the average atmospheric pressure of the next day from atmospheric pressure data of the previous day. A second-stage neural network forecasts the insolation level of the next day from the average atmospheric pressure and weather data of the previous day. A third-stage neural network forecasts the insolation of the next day from the insolation level and weather data of the previous day. Meteorological data at Omaezaki, Japan in 1988–1993 are used as input data, and the insolations in 1994 are forecast. The insolations forecast by the multi-stage and the single-stage neural networks are compared with the measured ones. The results show that the mean error reduces from about 30% (by the single-stage) to about 20% (by the multi-stage).

1. INTRODUCTION

A heat pump (HP) hot-water supply system has a high energy saving effect at the primary energy level. We proposed a solar heat hot-water supply system with HP hot-water system (Orita et al., 1994). From an economical viewpoint, it is advisable that the HP hot-water system is operated during the night, because electricity charge during the night is about 60% cheaper than that in the daytime. If the solar energy of the next day is sufficient, it is not necessary to operate the HP to heat a storage tank. On the other hand, if the solar energy of the next day is not enough, it is necessary that the heat-storage tank is heated by the night electricity through the HP. Thus, it is important for the solar energy/HP hot-water supply system to forecast the solar energy that will be obtained in the daytime of the next day.

We have proposed effective operation of a solar photovoltaic/heat utilization system, where the daily insolation of the next day was forecast from precipitation probability (Nakagawa et al., 1995). In that operation, the electricity charge decreased and the solar energy was utilized effectively, as the forecast error decreased.

A single-stage neural network (NN) has been applied to forecast the electric power demand of the next day (Ishida and Tamura, 1994; Sato and Tanaka, 1994). However, the single-stage NN is not applicable to forecast the insolation, because the insolation changes more vigorously day by day than the electric power demand (Orita et al., 1994). In this paper, the authors propose a multi-stage NN to forecast the daily insolation of the next day. In the multi-stage NN, the insolation level is roughly forecast at the first and second stage NN. Next, the insolation is forecast at the third stage NNs, where the NN used is selected in accordance with the insolation level. Using this multi-stage NN, the daily insolation in April, August, October and December at Omaezaki, Japan, are forecast. The insolation forecast by the multi-stage NN is compared with that by the single-stage NN.

The term 'insolation' used in this paper means the total global insolation integrated over 1 day, the unit being MJ/m^2 day.

2. INSOLATION DATA

The NN learns daily weather data of 6 years (1988–1993) and forecasts the daily insolation of 1994. Weather data of Omaezaki, Japan, are adopted in this paper. Those were measured by the Meteorological Agency. The average, maxi-

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