Chapter 4.14
Fuel Reduction Effect of the Solar Cell and Diesel Engine Hybrid System with a Prediction Algorithm of Solar Power Generation

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ABSTRACT

Green energy utilization technology is an effective means of reducing greenhouse gas emissions. We developed the production-of-electricity prediction algorithm (PAS) of the solar cell. In this algorithm, a layered neural network is made to learn based on past weather data and the operation plan of the hybrid system (proposed system) of a solar cell and a diesel engine generator was examined using this prediction algorithm. In addition, system operation without a electricity-storage facility, and the system with the engine generator operating at 25% or less of battery residual quantity was investigated, and the fuel consumption of each system was measured. Numerical simulation showed that the fuel consumption of the proposed system was modest compared with other operating methods. However, there was a significant difference in the prediction error of the electricity production of the solar cell and the actual value, and the proposed system was shown to be not always superior to others. Moreover, although there are errors in the predicted and actual values using PAS, there is no significant influence in the operation plan of the proposed system in almost all cases.

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INTRODUCTION

Utilization of the expansion of green energy is an effective method to reduce the amount of greenhouse gas discharge. However, energy supplies using green energy tend to be unstable, hence

interconnection with commercial power and operations to link to present generating equipment are required with the stabilization of the energy supply in mind. In recent years, there have been remarkable improvements in battery performance and the equipment cost has declined. Therefore, it is considered that the operation optimization method for green energy, including the storage of electricity, will henceforth become important. The objective of this study involves developing an algorithm (PAS) to predict the electricity production of a solar cell, and to optimize the operation of a diesel-power-plant hybrid system with the green energy of unstable output power (Obara, S. & Tanno, I. (2008(1))). Moreover, the relation between the prediction error of the PAS and the energy cost of the proposed system is clarified. To date, there has been considerable research concerning the operation plan of a hybrid system, combining a solar cell and a diesel power plant (Ashari, M., & Nayar, C. V. (1999), Muselli, M., etc. (1999), Ismail, Y., etc. (2002), Yamamoto, S., etc. (2004)) . These research reports show that a reduction in energy cost can be realized by both the electricity production of a solar cell and the power load being predicted. If a large scale computer and considerable weather observation data are used, the solar radiation several hours later in arbitrary locations may be predictable (Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology (2008)). In this case, the electricity production of the solar cell can be correctly estimated. However, since using this method is costly in terms of communication and information, in this paper, a simpler algorithm for predicting the production-of-electricity of a solar cell is developed (PAS). In the PAS algorithm, a layered neural network (NN) is made to learn using data on the amount of solar radiation and outside temperature for the past 14 years (NEDO, and the standard weather and the solar radiation database in 1990 to 2003 (METPV-3) (NEDO Technical information data base, (2008))). As teaching data in this case, the electricity production of the polycrystalline-silicon-type solar cell, as calculated from the amount of slope-face solar radiation, is introduced. The weather data (the amount of solar radiation and outside air temperature) of each period, ranging from 24 hours earlier to the present, is given to the learned-NN, and the solar cell output power until several hours have been predicted and the operation of the engine and battery is planned based on this prediction result. Therefore, in this paper, the variables are defined as the solar cell area and the battery capacity and the influence of the operation cost is clarified, while an allowance for error is included in the PAS prediction result. Furthermore, the fuel consumption of an engine generator is compared with a system where the prediction operation plan has not been installed.

System Configurations

Combined Solar Cell and Diesel Engine System

Figure 1 is a schematic diagram of a combined solar cell and diesel engine system. The power of a solar cell can be supplied to the demand side via a DC-AC converter and inverter. Moreover, this power can also be used to charge a battery through a DC-DC converter. The power of an engine generator is supplied to the demand side through an inverter, while the power of the engine generator can also be used to charge a battery through an AC-DC converter. The specification of the engine and the power generator are shown in Tables 1 and 2, respectively, while the engine output is transmitted to a power generator by a belt.

Data concerning the present weather intelligence (the amount of slope-face solar radiation and the outside air temperature) and the extent to which the battery is charged are input into a system controller. The PAS is then introduced into the system controller and the predictive value of a solar cell output can be analyzed (Obara, S., & Tanno, I. (2008(2))). In this system controller,