研究論文

An Operating Method for Fuel Savings in a Stand-Alone Wind/Diesel/Battery System

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Abstract

A new method for operating a stand-alone wind/diesel/battery system is presented in this paper. The system, especially its diesel generator, is controlled so that a given constant battery charge level may be maintained, i.e., the battery is charged when the charge is lower than the constant level and discharged when higher. A simulation was carried out over one year using the hourly data of electric load and wind speed on Kamishima Island, Japan in 1996. This method was compared with other methods; a conventional operating method maintaining the battery at the fully charged level and a dynamic programming operation method (DP method). The results show that for diesel generator fuel consumption, this method is superior to the conventional method, although not to the DP method, and that for excess energy this method is much better than the conventional method and as good as the DP method.

Key Words : wind/diesel/battery system, simulation, operating method, battery charge level, fuel consumption, excess energy.

1. Introduction

Many stand-alone wind/diesel/battery systems have been installed on remote islands [1-4]. It is required to operate the system so that the fuel consumption of the diesel generator is minimized without causing any blackout, in order to reduce the primary energy consumption and the fuel cost during the system running. In such operation[5-8], the battery has the role of storing surplus energy or of assisting a wind turbine generator. If the battery is used to store surplus energy, the battery charge level has to be kept low. On the other hand, if the battery is used to assist a wind turbine generator, its charge has to be kept high. Thus, the operating method of the battery differs with the purpose for which it is used.

A new method of operation is investigated in this paper. The diesel generator is so controlled that the battery charge level is kept constant between the minimum (20%) and maximum level (100%) of battery capacity. Here, this is called the CCL method. In this method, the battery is charged when its level is less than constant, and discharged when it exceeds it. A simulation was performed for over one year using the hourly data of electric load and wind speed on Kamishima Island, Japan in 1996. The most suitable battery charge level was pursued, i.e., the level at which fuel consumption is lowest.

The CCL method is compared with other methods[8] from the viewpoints of annual fuel consumption and excess energy.

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（原稿受付：2001年8月30日）

2. System Configuration

Energy flows in the stand-alone diesel/wind/battery system are shown in figure 1, in which $Pw(t_i)$ is the output energy from a wind turbine generator (WTG), $Pd(t_i)$ is the output energy from a diesel generator (DG), $Pb(t_i)$ is the output energy from a battery, $Pl(t_i)$ is the energy consumed in an electric load, and t_i is the hourly time over one year (i = 1, 2, ・・・, 8760). They have to satisfy the following equation. $Pb(t_i)$ is positive when the battery is discharged and negative when charged.

$$Pw(t_i) + Pd(t_i) + Pb(t_i) = Pl(t_i) \qquad (1)$$

3. Electric Load and Wind Energy

The hourly data of electric load and wind speed adopted in this study were recorded on Kamishima Island, Aichi Prefecture, Japan in 1996. Their monthly variations are shown in figure 2. The electric load is high in July and