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Power Management Strategy Based on Weather Prediction for Hybrid Stand-alone System

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Abstract

This paper presents an intelligent strategy for optimal power management of stand-alone hybrid system. The designed management strategy aims at regulating the power flow between the generated and the consumed powers of a wind/solar/battery stand-alone system in order to satisfy the load (one family house). The chosen strategy considers the wind generator (*WG*) and the photovoltaic panel (*PV*)as the main energy sources and the battery bank (*BS*) as storage system. For the power source emergency, it uses the diesel engine (*DE*) as an additional source. Indeed, the optimal management strategy consists of generating power references for each subsystem. Based on the prediction of weather conditions, these power references are generated with taking into account some constraints related to the reliability of each subsystem.

In order to validate the proposed strategy under real situations, measurements of the weather conditions and the power consumption data of an individual house are considered. The simulation results are highlighted to demonstrate the feasibility of our approach.

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Keywords: Power Management,Renewable Energy, Prediction, *ANFIS*.

1. Introduction

The current global energy situation is becoming increasingly critical. This situation is induced, on the one hand by the increased energy consumption due to the population's growth and on the other hand, by the considerable technological development of a variety of energy dependent systems. Moreover, these energy requirements largely come from fossil fuels that emit greenhouse gases, and whose reserves are largely weakened during decades. The excessive use of fossil fuels threatens the availability of its world reserve since most machines and engines are fueled with it [1]. Considering the current global petroleum resources are expected to be used up within 50 years if they are consumed with the present consumption rates [2], new technologies of energy production from renewable sources, like solar or wind energy are receiving much high attention worldwide.

Recently, there have been many proposed technical projects in the development of the combination of different renewable energy sources which are mutually complementary in order to maximize efficiency and ensure supply without

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intermittence of the isolated areas; resulting in the popularity of the use of hybrid systems in recent years as those proposed in [1,3–6]. The hybrid renewable energy systems have been introduced as green and reliable power systems for remote areas. It depends therefore on the geographical and meteorological conditions of the target region.
There is a steady increase in usage of hybrid renewable energy systems and consequently, optimal strategies for power flow management of the system are required. With respect to the literature, several works deal essentially with sizing or economics study and management of stand-alone hybrid systems [3,4], [7,8]. In [9], the authors are focused on the control of $dc - dc$ converters which are linking the multi-source system with the dc bus. As a control strategy, a sliding mode control has been used in order to regulate the dc bus and track power references of each source.
In this paper, we propose to design an optimal management algorithm based on prediction of the wind-solar energy potential and the power consumption of the load over a time horizon. The prediction power allows to take good decisions according to weather conditions and load consumption. Based on these predictions, the management algorithm searches for the solutions which can satisfy the cost function of a suitable optimization problem subject to some constraints over the time horizon. To do this, a power management strategy for the hybrid wind/solar based system is designed. Moreover, the use of only wind and photovoltaic system with battery storage may not track the load demand. Another kind of source must be added [10,11], in our case, a diesel engine is chosen as emergency source.

2. Hybrid System description

Stand-alone hybrid generation systems are usually used to supply remote areas or locations interconnected to a weak grid. They combine several generation modules, typically assimilating different renewable energy sources. In this work, a wind-solar system is considered as main energy source. A lithium-ion battery bank is used to overcome the periods of poor production. In fact, the battery operates as secondary source for supplying the power deficit caused by the dynamic power balance [12]. In addition to these sources a DE is used as backup source. The considered system is illustrated by figure 1. As it is previously mentioned, this topology uses WG and PV subsystems as the main energy

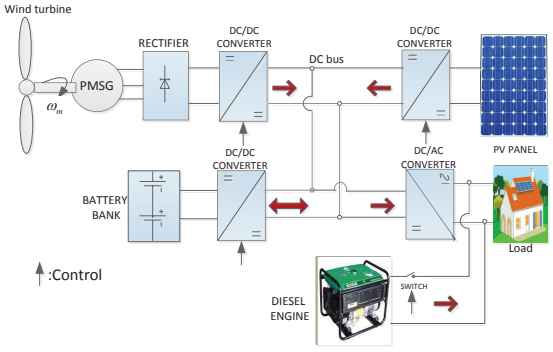

Fig. 1: Architecture of the power hybrid system

sources. These subsystems operate in parallel to inject the converted power into the dc bus. The WG used in our case is based on a permanent magnet synchronous generator ($PMSG$). This type of generator has become popular for wind conversion systems especially for small variable-speed turbines due to their advantages over other types of wind turbines [13]. Furthermore, due to the intermittence of the wind and solar energies taken separately, the association of this sources offers a good solution for this kind of isolated system. However, a storage system like a battery or a superconductor remains indispensable to ensure power supply of the load without interruption. Consequently, the storage system based on lithium-ion battery is considered. Due to their advantages like light weight, low self-discharge rate, and high specific energy, Lithium-ion batteries have become one of the most popular type of batteries in various applications such as portable devices, electric vehicles and renewable energy systems [14,15].