Smart power management of a hybrid photovoltaic/wind stand-alone system coupling battery storage and hydraulic network

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Abstract

An off-grid energy system based on renewable photovoltaics (PV) and wind turbines (WT) generators is coupled via converters to electric and hydraulic networks. The electric network is composed of consumers and of a battery bank for electrical storage, while the hydraulic part is made of motor-pumps and hydraulic tanks for water production and desalination. Both battery and water tanks are used to optimize the power management of both electric and hydraulic subsystems by ensuring electric load demand and by reducing at the same time water deficit following the operation of the renewable intermittent source. Thus, both electric and hydraulic subsystems are strongly coupled in terms of energy making necessary to manage the power flows provided by renewable sources to optimize the overall system performance. In this paper, two kinds of management strategies are then compared in the way they share the hybrid power sources between the storage devices (battery and tanks) and the electrical/hydraulic loads. The first approach deals with an uncoupled power management in which the operation of electrical and hydraulic loads does not depend on the state of the intermittent renewable sources: in particular, hydraulic pumps are operated only taking account of water demand and tank filling but without considering power sources. On the contrary, given the available power produced by the sources, the second class of strategy (i.e. the “coupled management strategy”) consists of a “smart” power sharing between the electrical and hydraulic networks with regard to the battery SOC and the tank $L_1$ and $L_2$. A dynamic simulator of the hybrid energy system has been developed and tested using a MATLAB environment. The system performance is shown under the two investigated approaches (uncoupled vs coupled). Several tests are carried out using real meteorological data of a remote area and a practical load demand profile. The simulation results show that the “coupled strategy” clearly outperforms the classical “uncoupled” management strategies.

Keywords: Hybrid energy system, Battery storage, Hydraulic storage, Hydraulic system, Dynamic simulator, Smart power management.

1. Introduction

Off-grid power supply systems based on renewable energies are of great interest for applications such as remote areas electrification, telecommunication station powering, water pumping and/or desalination for...
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