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Fuzzy logic energy management for a photovoltaic solar home

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Abstract

This paper presents a new energy management strategy for supplying a home with a grid-connected photovoltaic system with a backup. The proposed energy management algorithm is based on a fuzzy logic technique. A strategy has been elaborated in order to manage the home energy demand depending mainly on the energy available from the PV system and according to an established load priority, which is adjusted to satisfy the user's energy needs and comfort. The case studied concerns a home installed in a coastal region of Bou-Ismaïl (Algeria). The efficiency level of the PV system has been shown through a favourable week in summer (August 2016) and an unfavourable week in winter (January 2016) using the real weather conditions of the site.

The developed Fuzzy Home Energy Management has permitted to save 26.49% and 25.54% of energy respectively in winter and summer when compared to the consumption of the same home in the same conditions but without any energy management and or just using a basic load priority.

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Keywords: photovoltaic (PV); Fuzzy logic technique, Solar home, Home energy management; Consumption profiles;

1. Introduction

The fulfilment of the ever-increasing energy demand, while taking into account both the depletion of fossil resources and the preservation of the environment, requires a deep change of the grid.

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This would be done mainly by adopting the smart grid concept, which induces the transition from a centralized generation and distribution system to a decentralized and bidirectional electrical network. This new architecture of the electricity grid calls for the use of power stations using renewable energy sources, particularly photovoltaic, which are suitable for the decentralization even if their intermittent aspect remains a challenge. As the residential and tertiary sector is the most energy intensive sector, housing consumption appears as a cornerstone in the grid mutation. The objective to be achieved when using solar photovoltaic in the residential sector is to satisfy the energy demand of the house in a sustainable manner by the locally photovoltaic energy produced while preserving the comfort of the users. This requires an efficient Home Energy Management System (HEMS).

During the past decade, several approaches have been used in order to develop HEMS. Therefore, S. A. Shinde [1] proposed a HEM system with Demand Response (DR), in which different loads are used and corresponding priorities were adjusted. S Althaher and AL. [2] have developed an optimized home energy management controller which manages the appliances in response to dynamic price signals to reduce the consumer's electricity bill with decreasing the energy consumption and considering the user's comfort. Di Giorgio and Al. [3] examined an optimal energy management controller of a smart home in the case of Demand Side Management (DSM) and Time Of Use (TOU) Tariffs and reasonable results were obtained conducting to economic savings. Several techniques are available for the implementation of the energy management algorithm [4, 5]. Among them we have chosen the fuzzy logic [6, 7] technique which offers several advantages; it does not require an exact mathematical model of the studied system, it offers low power dissipation and an optimized cost, it is reliable and stable [8].

The present work is organized as follows. In Section 2, the chosen photovoltaic system which feeds the home is presented. Section 3 mentioned the chosen production profile and load profile used in our study. The proposed energy management system is presented in Section 4, while in Section 5; the results of the simulation are given and discussed, using the MATLAB-SIMULINK. The conclusion is given in Section 6.

2. PV System description

The optimal PV system configuration used to feed the house has been obtained by using the PVSYST [9] using the real irradiance and temperature data of the site , autonomy of one day and the home load profile. This has conducted to a PV array of 3.2kWp, a battery bank of 12kWh and a 4kW DC/AC converter [10]. The home energy needs satisfaction, which must be fulfilled mainly by the locally PV produced energy, as shown on Fig. 1, depends on the energy demand of the home, the PV energy produced, the State Of Charge (SOC) of the battery bank and the energy imported from the grid. In order to achieve the best match between production and consumption in the house, a fuzzy logic energy management system has been developed.

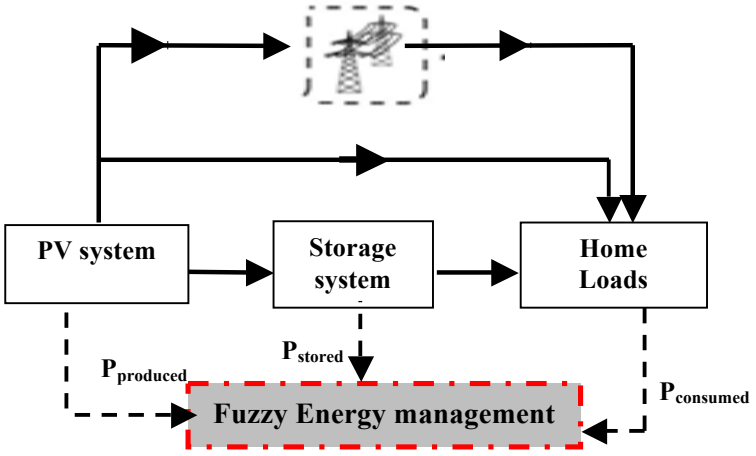

Fig. 1. Description of Grid-connected PV system with storage for the solar home.