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An energy flow management algorithm for a photovoltaic solar home

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Abstract

In this paper, an energy flow management algorithm for a grid-connected-photovoltaic system with battery storage devoted to supply a home is presented. This algorithm favours the fulfilment of the home energy demand by the energy produced by the photovoltaic generator or stored in the batteries than that got from the grid. This algorithm manages the flow of energy in the house through the combination of four switches. It was applied to the case of a home installed in a coastal region of Bou-Ismaïl (Algeria). The efficiency of the algorithm was tested for two weeks, a favourable week in summer and an unfavourable week in winter regarding the weather conditions. The simulation of the on grid PV system was done using real data of the irradiation and the temperature acquired by the meteorological station of the Bou-Ismaïl site and a home load profile for each season. The results obtained revealed that the energy demand satisfaction for the house is high in the favourable summer week and is only 33% in the winter unfavourable week. To meet a high rate of self-consumption a Home Energy Management is required.

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1. Introduction

In an energy environment where the energy demand is continuously growing, the fossil resources are declining and the global warming is dramatically increasing, many countries have opted for the adoption of measures to reduce energy consumption and for an energy transition using renewable energy sources.

This implies a new architecture of the energy supply system, which moves from a centralized to a decentralized

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generation. In this context, photovoltaic (PV) generation appears as the most promising alternative thanks to its maturity, its environmentally friendly characteristics, low maintenance and the fact that the sun is everywhere.

The residential and building sector is in many countries the first energy consumer, about 40% of the global energy consumption [1], therefore efficient utilization and control of energy consumption at household level is crucial [2]. The challenge resides in the matching of the intermittent energy production with the dynamic power demand [3]. This needs to design an energy management strategy in order to optimize the use of PV source and storage and to match the local production with local consumption. The available energy produced by these sources and the home energy demand while insuring user comfort.

In the literature, several works are particularly focused on optimizing the energy. This optimization is based on the study and analysis of the houses consumption profiles. Consequently, studies have been directed to "smart homes" [4-7]. In this paper the case of a home powered by on grid photovoltaic system with storage is investigated. An energy flow management algorithm was developed. It manages the energy flow available in the home through a combination of switches to meet the energy demand optimally using the energy produced by the photovoltaic generator and/or the energy stored in the batteries and/or the energy drawn from the grid. The purpose is to minimize this last and ultimately reach the self-consumption mode. Two particular weeks have been chosen, one in summer and one in winter, in order to tests the algorithm.

The paper is organized as follows. In Section 2, the chosen photovoltaic system which feeds the home to satisfy the energy demand profile is presented. The models used to simulate the PV system are given in section 3. The proposed energy flow management algorithm and the operating mode of the system are presented in section 4, while in Section 5, the obtained simulation results, using the MATLAB-SIMULINK are given and interpreted.

2. PV System description and energy demand of the home

2.1. Description of the proposed PV system

In order to study how to meet the energy needs of a family by using mainly the energy produced by a photovoltaic installation, the sizing of the PV system has been done by using PVSST 1.0 locally developed software [8], which used real irradiation and temperature data of the site, an autonomy of one day and the home load profile. The optimal PV system configuration obtained is an array of 3.2kWp and a battery bank of 12kWh. To feed the loads of the house, 4kW DC/AC converter has been chosen. In order to prevent the batteries from a total discharge, the lowest level of the State Of Charge (SOC) was set to 25%. This SOC corresponds to a capacity of 3kWh. The SOCmax was set to 85% which corresponds to 10kWh. As shown on figure 1, the PV system operation depends on the combination status of four switches (K1, K2, K3, K4) which is related to the energy demand, the energy available from the PV generator, the SOC of the battery bank and the energy taken off from the grid. In order to meet optimally the energy needs of the home, an energy flow management algorithm has been developed.

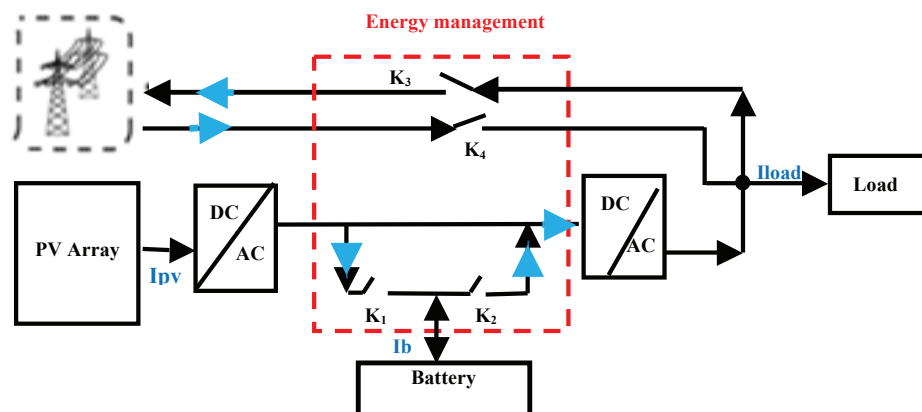


Fig. 1. Grid-connected PV system with storage for the solar home.

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