Cooperative Dynamic Power Balancing and Smoothing in a Photovoltaic/Hybrid Energy Storage System Using Multiple Reactive Agents

Abstract_ Photovoltaic (PV) systems are one of the fastest-growing types of renewable energies that significantly contribute to the transformation of the global energy sector. Balancing the PV's generated power and load is essential to ensure the stability and enhance the reliability of the system. However, it is challenging due to the limitation on the availability of power and intermittency of generation. This challenge can be tackled by using hybrid energy storage systems (HESS). HESSs play an important role in dynamic power balancing; moreover, they are essential for the effective integration of PV Systems. The appropriate operation of HESS requires advanced control and management techniques. This research proposes a distributed hybrid control strategy for dynamic power balancing and smoothing in a photovoltaic (PV)/hybrid energy storage system. The system contains a PV system, a HESS including a battery energy storage and a supercapacitor, and a group of interconnected loads. Each system's module is considered as a reactive agent that may change its state or operational mode upon satisfying a predefined condition. In the proposed approach there is no central controller or coordinator agent, and the decisions are made by the agents that directly communicate with each other. The interaction of the agents emerges a global pattern that provides a reliable and efficient power balancing and smoothing performance for the case study system. The simulation results show that the proposed control strategy can improve the system efficiency and performance by maintaining the balance between generation and load as well as reducing the required size of the supercapacitor.

Keywords*: Renewable energies, multi-agent systems, hybrid automata, rule-based power management.*

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