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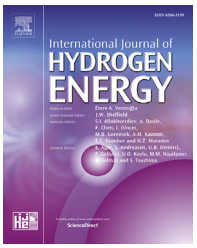

Novel energy management method for suppressing fuel cell degradation in hydrogen and electric hybrid energy storage systems compensating renewable energy fluctuations

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ABSTRACT

This research investigates an energy management method utilized in a hydrogen and electric hybrid energy storage system (HESS), which is utilized as an ancillary system for renewable energy electricity generation. To suppress the performance degradation of the fuel cell (FC), the newly proposed energy management method deals with main FC degradation causes, such as low humidification and frequent and rapid voltage changes. The entire HESS's performance is demonstrated using the proposed energy management method. In addition, a simulation is conducted to evaluate the proposed energy management method's performance in terms of both suppressing the FC's degradation and ensuring system efficiency. The results of the experiment and simulation show that the proposed energy management method can suppress the FC's harmful working states while maintaining high system efficiency.

Introduction

Background and literature review

Distributed renewable energy electricity generation is receiving a lot of attention nowadays [1,2]. It is a promising solution to the power supply problem of important installations, like hospitals and factories, both for everyday use and for use during emergencies. To satisfy the large power demand of important installations, a large-scale renewable energy source requires a matching ancillary energy storage device with sufficient capacity and response speed. In addition, the restricted space in existing important installations indicates that this energy storage device requires a high energy density.

Given this problem, based on previous research [3–9], a kind of hydrogen and electric hybrid energy storage system (HESS) that can efficiently convert fluctuating renewable energy into a stable power supply for important installations has been proposed [10]. Its schematic is shown in Fig. 1. The mechanism of its energy management method can be summarized as follows: Using a Kalman filter prediction algorithm, the power difference between renewable output power and real-time load power is resolved into long and short period components. Major fluctuations (long period) are

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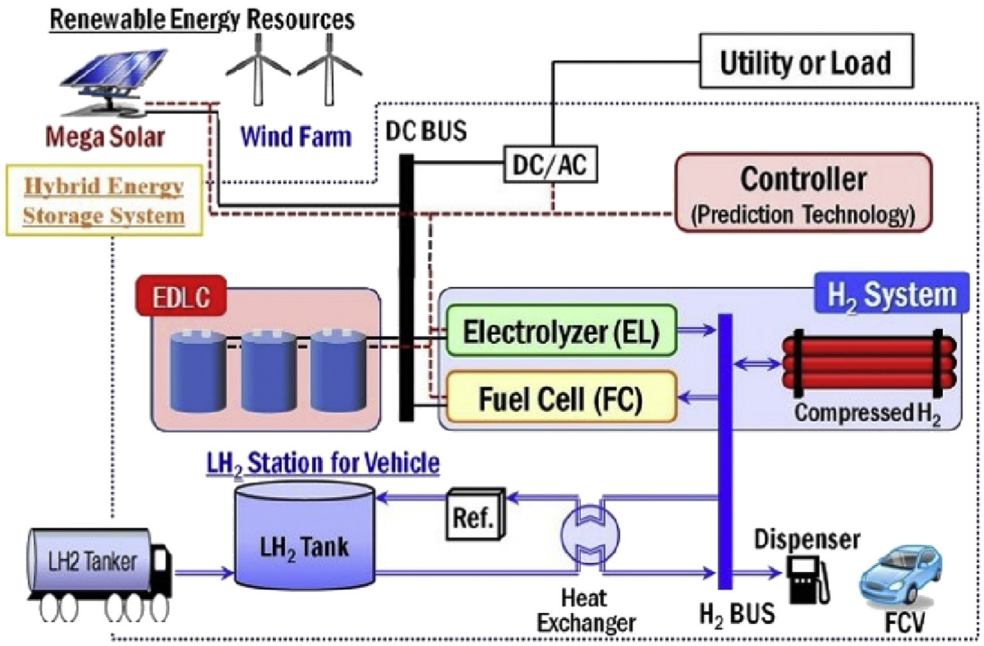

Fig. 1 – Schematic figure of a hydrogen and electric hybrid energy storage system, composed of hydrogen energy storage system (electrolyzer, fuel cell and hydrogen storage facilities) and electric energy storage device (electric double-layer capacitor) [10].

compensated by the hydrogen system, and transient fluctuations (short period) are compensated by the electric double-layer capacitor (EDLC). Fig. 2 gives an example of this process [11]. A detailed description can be found in Refs. [10,11].

Present problems: fuel cell (FC) performance degradation and system efficiency

Using the energy management method mentioned in Section Background and literature review, the demonstration of this HESS has been achieved. However, FC performance degradation occurred much earlier than expected under this working state due to the FC's varying demanded power. Therefore, in this research, degradation factors were analyzed to create an effective energy management method that can suppress FC degradation. Furthermore, since this HESS was expected to efficiently convert renewable energy into a stable power supply, an efficiency comparison between different energy management methods was also performed.

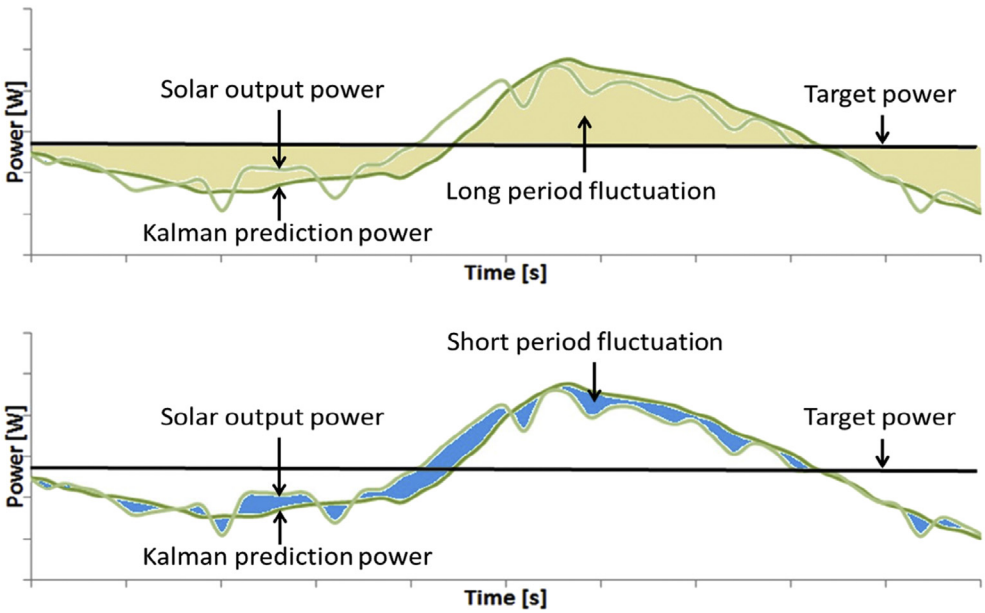

Fig. 2 – Kalman filter prediction algorithm resolves solar power fluctuation into long and short period components [11].

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