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Demonstration Experiment for Energy Storage and Rapid Charge System for the Solar Light Rail

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Abstract

An application of renewable energy is expected. However, renewable energy such as solar and wind is unstable. Therefore, thermal power plants are necessary to operate solar power plants and wind turbines on commercial power supply. In this paper, a rechargeable system for renewable energy application is proposed and a demonstration experiment using rideable model railroad is reported. The electric double layer capacitor (EDLC) unit of 17.5 V - 171.4 F is charged by solar panels, and another EDLC unit of 15.0 V - 100 F mounted on the railcar is charged rapidly from EDLC unit connected to solar panels. A railcar run by charged energy on 9 meters of strait rail. Although the experiment was carried out in January, only two weeks after of the winter solstice, the rapid charge was carried out 56 times and the railcar ran for 9 hours a day. It was confirmed that this method, using EDLC as energy storage device and rapid charge from EDLC to EDLC, is effective throughout a day.

Keywords: transportation; renewable energy; energy storage; electric double layer capacitor; rapid charge

1. Introduction

Railways are known as environmentally friendly transportation system. CO_2 emission and energy consumption of rail transport is lower than that of road transport [1]. Moreover, a light rail (known as tram, streetcar) does not divide the town like a railway and people can cross a rail easily. A light rail is friendly

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not only for environment but also for people. However, fossil fuel power generation accounts for over 60% of all electric power in Japan. When railways, especially light rails, can run on renewable energy such as solar, wind and hydro power, it will be more environmentally friendly transportation system.

In most of previous works to make railways run on renewable energy especially solar power, solar panels are installed along the rail in order to obtain accepted electricity, and electricity is supplied to the railcar in real time [1-2].

A rechargeable run system named "The Solar Light Rail" is proposed [3-5]. Fig. 1 shows the power supply method of this system. Solar panels are installed on the roof and around the station. Wind turbines and water wheels are built around the station. A unit of electric double layer capacitor (EDLC), called as "the primary EDLC," is installed at the station as an energy storage device, and the primary EDLC is always charged from solar panels, wind turbines and water wheels. There is a short contact wire for rapid charge at the station [6]. An EDLC unit, called as "the secondary EDLC," is mounted on a railcar. When the railcar stops at the station, electricity is rapidly transmitted from the primary EDLC to the secondary EDLC. The railcar charges electricity only to reach the next station at each stop.

In this system, energy storage devices repeat charge and discharge. Advantages of EDLC such as long life, high input-output power and low pollution [7], are suitable for this system. The amount of energy stored per unit weight is lower than that of batteries. However, usually distance between stations of light rails is shorter than that of railways. Therefore, that cannot become a disadvantage in this system.

According to the test outcome by the Railway Technical Research Institute of Japan, their hybrid light rail vehicle named "Hi-tram" consumes 2.5 kWh of electricity per kilometers at the maximum air conditioning load [8-9]. If the Solar Light Rail line is assumed as follows, the power generation capacity of 99,000 kWh is required a year at each station.

- Interval between stations is 500 m.
- A railcar arrives and departs every 10 minutes.
- The operation time is 6:00 to 24:00.

If required electric power can be supplied, it is feasible in the calculation to run the light rail only by renewable energy [4].

Experiments were carried out using a prototype model in order to substantiate the proposal. Fig. 2 shows the energy flow of this system. The stage of charging the primary EDLC by solar panels and the stage of running with charged EDLC were already carried out [5]. The stage of rapid charge from the primary EDLC to the secondary EDLC is carried out this time, and whether this system functions through a day is verified.

2. Experimental Equipment

2.1. Power generation equipment

Two types of solar panels are used in this experiment. One is a mono-crystalline silicon solar panel. Circular cells are wired 11 in series - 3 in parallel. It has been used more than 20 years. However, open circuit voltage of 19 V and short circuit current of 3 A is still measured in preliminary experiments. This solar panel is called as "solar panel 1" in this paper.

Another is a poly-crystalline silicon solar panel. This solar panel is fabricated with 50 solar cells. Rectangular cells are wired 10 in series - 5 in parallel. Open circuit current of 17.5 V and short circuit current of 3 A is measured. This solar panel is called as "solar panel 2" in this paper.