A kW-Vanadium Flow Battery System Integrated with Solar Power

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Abstract

A smart energy storage system comprises a 2 kW/10 kWh vanadium flow battery integrated with a 4.5 kW solar power which was connected by the DC power. Solar power has the priority to charge energy storage battery. The surplus solar power could supply to the demand of factory power. Energy storage system and solar power simultaneously supply power to the street lights and power of factory after 5:00 PM every day.

The vanadium flow battery system has the advantage of long life time. This demonstration system is capable of monitoring the energy storage status. The operating status of system reveals some key factors including system component maintenance and system design refinements for the reference of operating a large scale system. To improve the disadvantage of flow battery system running at low rated power, this hybrid energy storage system under the DC power management promote energy efficiency and the utilization percentage of integrated system.

Keywords: Vanadium, flow battery, solar, integrated, energy storage

Background

Popular renewable energies including wind and solar power are intermittent [1]. Creating a scenario that is the part of renewable used as base load power achieves the best utility of integrated renewable energy and energy storage system [2]. Long time energy storage systems (10+ hour) will become a trend in the future applications [3].

Power Management Diagram

Grid, solar, loads and battery are integrated together by the DC power(Figure1). The electricity flows of grid and battery are two way. Power of grid, solar and loads are respectively transformed by AC-DC, DC-DC and DC-AC conversions. Figure 2 shows power control strategy in the energy storage system. We suppose that grid, solar, loads and battery are integrated in the DC power pool. Blue line indicates the capacity status of energy storage system reflecting under the DC power potential. Power flow is determined by the setting of DC power potential (voltage) of grid, solar and battery. Power is determined by power potential and power flow (current, circle size) of grid, solar, battery and loads, respectively.

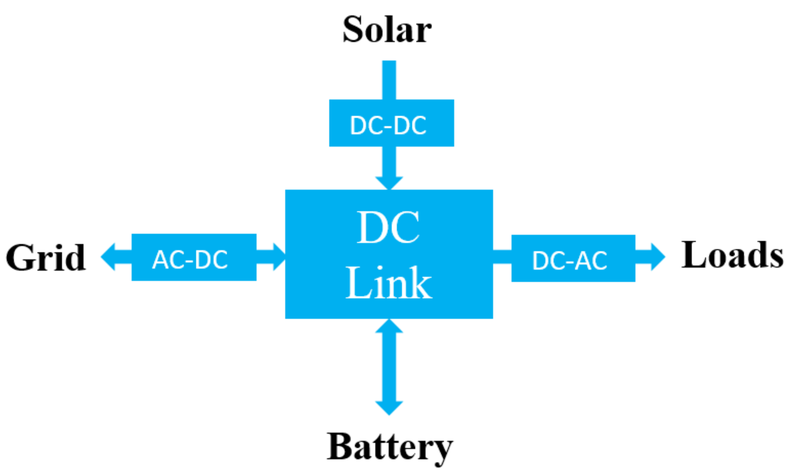

Figure 1. Power connection architecture.

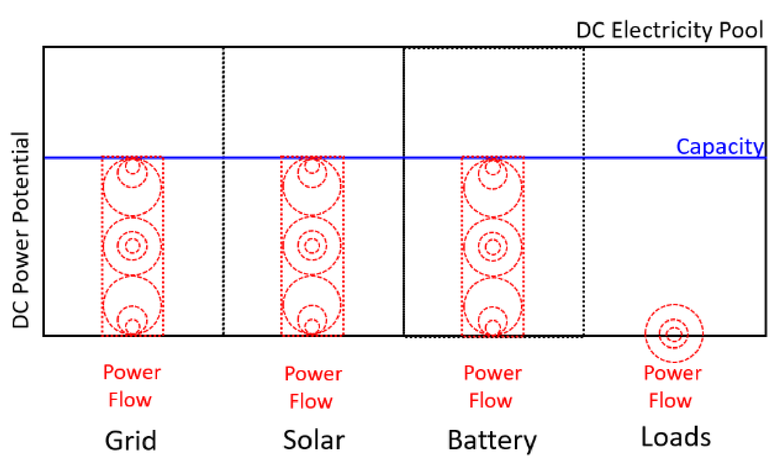

Figure 2. Power control strategy.

Figure 3. 2 kW/10 kWh vanadium flow battery system integrated with solar power.

Status I
Automatic inner-grid use (Solar stable)
100 % solar utilization + Automatic charge battery

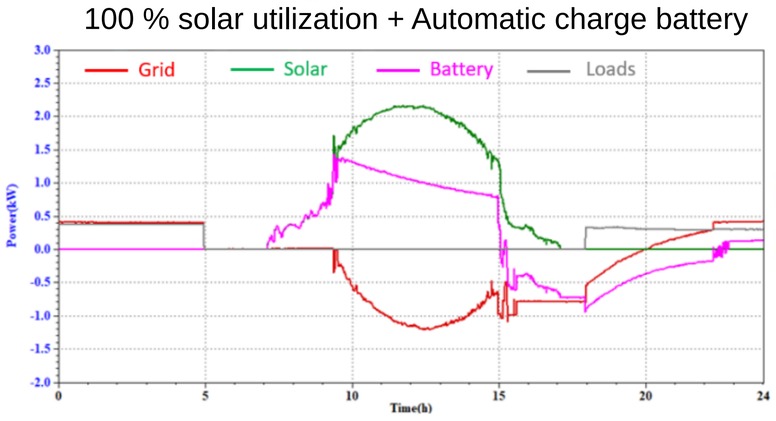

Figure 4. All day power operation curves of grid, solar, battery and loads (status I).

Status II
Planned inner-grid use (Solar stable)
100 % solar utilization + Automatic charge battery

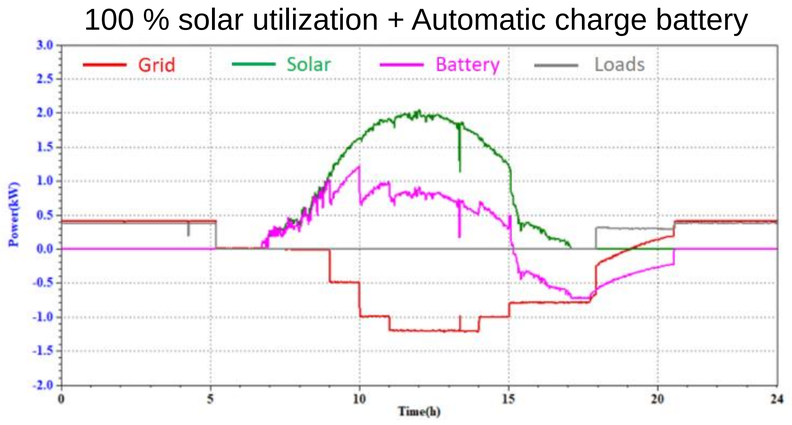

Figure 5. All day power operation curves of grid, solar, battery and loads (status II).

Status III
Automatic inner-grid use (Solar unstable)
100 % solar utilization + Automatic charge battery

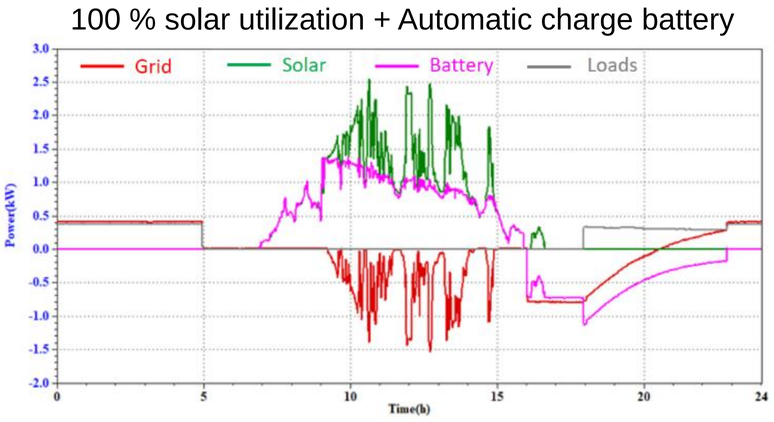

Figure 6. All day power operation curves of grid, solar, battery and loads (status III).

Conclusions

Long-term energy storage system is the future development trend as the proportion of renewable energy continues to increase. The cost and safety may be one of the determined key factors. Flow batteries have great development potential. Flow batteries hybrid with high power batteries that effectively promote the energy efficiency and the utilization percentage of integrated system expand the application fields.

Acknowledgements

This work was financially supported by a project of the Bureau of Energy, Ministry of Economic Affairs, Taiwan, Republic of China

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