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A Rule-Based Energy Management Scheme for Uninterrupted Electric Vehicles Charging at Constant Price Using Photovoltaic-Grid System

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Abstract—This work proposes a rule-based energy management scheme (REMS) for electric vehicle (EV) charging from photovoltaic-grid (PV-grid) system. The main feature of this scheme is that it provides uninterrupted daytime charging at a constant price. In order to simulate the system, the models of PV output power, EV power demand, state of charge (SOC) estimation of energy storage unit (ESU) and grid electricity prices are developed. The uninterrupted and constant price charging is achieved by managing the energy flow between PV, ESU and grid according to the rules defined by REMS. Furthermore, the valley-filling operation is implemented during the grid off-peak hours. The resiliency of REMS is validated under various weather conditions, different ESU prices and at grid parities. For comparison, its performance is benchmarked against the standard grid-based EV charging. The results demonstrate a decline in charging price by 16.1% besides reducing the burden on the grid by 93.7% with the implementation of REMS. In addition, the vehicle-to-grid (V2G) technology is incorporated in the charging system to improve the payback schedule of the existing PV-grid system.

Keywords—Constant price charging, renewable energy, electric vehicles, energy management scheme, Photovoltaic-grid system, rule-based algorithm.

1. INTRODUCTION

The direct charging of electric vehicles (EV) using standard electrical grid outlet is widely accepted due to its simplicity and the provision of unlimited energy source [1]. However, it imposes an extra burden on the supply—particularly during the daytime where the electricity demand is at its peak. The grid overloading results in voltage/frequency deviation, distribution losses, and degradation in the power quality [2]. To overcome these consequences, a hybrid charger using renewables energy (RE) is proposed [3, 4]. Additionally, the environmental benefits of using RE source are well understood among power engineering practitioners for providing electrical energy [5-7]. Among the RE sources, solar photovoltaic (PV) appears to be well-suited for daytime charging, where the demand is highest and coincides with the peak tariff [8, 9]. Photovoltaic-grid (PV-grid) systems have been spread in many countries because of its potential long-term benefits [10, 11]. Furthermore, the PV system can be installed in existing buildings or car parking space [12]. In the latter case, the roofed structure provides shelters from sun and rain, which is favorable in hot climate countries. In addition, the availability of solar power enables the prospect for “charging while parking” [13],
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