Abstract

For the sustainable future of a microgrid with energy storage, the important criterion to its consumers are affordability and reliability of power supply. In a photovoltaic (PV) battery microgrid, the battery life is a critical factor as it directly correlates with the life cycle cost of the system. The battery lifetime given by the manufacturer is limited only to ideal conditions. In practical contexts, these vary and are closely dependent on operating and ambient conditions. In addition, battery manufacturers specify their End of Life (EoL) condition at 80% of rated capacity (i.e., 20% battery degradation). There exists a trade-off between cost and reliability, when the end of life of the battery is extended beyond the manufacturer specifications. This paper models this trade-off and calculates battery degradation rates in a microgrid, which can be utilised in refurbishing the optimal design solution of the system. The PV battery microgrid along with the capacity fade of the battery is modelled for Indian contexts. The solar irradiance and the ambient temperature of five different climatic zones of India along with the synthetic load of a hamlet with twenty households are given as inputs and its battery degradation rates are computed. The system is further simulated beyond the battery EoL by considering both PV and battery degradation to evaluate the trade-off between cost and reliability. The results indicate that the end of life condition of battery should be selected based on acceptable levels of reliability. As an example, for a 2 V, 500Ah valve-regulated lead-acid (VRLA) battery with a rated service life of 10 years (80% end of life and 25 °C) will last only 4.8 years in the hot and dry climate of Jodhpur, India when the continuous capacity fade is considered. If the acceptable reliability levels are at 3%, then the battery will last for eight years with an end of life condition at 66% of the initial capacity. As a result, the life cycle cost of the system reduces from 26.5 to 20.6 ₹/kWh.