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Analysis of the dynamic power requirements for controllable energy storage on photovoltaic microgrid

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2016

http://hdl.handle.net/10539/22674

Horonga, Nyasha (2016) Analysis of the dynamic power requirements for controllable energy storage on photovoltaic microgrid, University of the Witwatersrand, Johannesburg, <http://hdl.handle.net/10539/22674>

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Abstract

Standalone microgrid studies are being done because an expansion of the existing utility grids to supply power to remote communities is not feasible. Standalone microgrids can be considered as one of the solutions for remote communities because power can be generated close to these communities and it minimizes cost related to power transmission. Renewable energy sources with large fluctuations are frequently the source of power for these standalone microgrids. The fluctuating nature of these renewable sources can often lead to frequent blackouts. This research is aimed at minimizing power fluctuations using controllable energy storage systems. This MSc focuses on the analysis of the ramp rate and delay time requirements for controllable energy storage system used in standalone PV microgrids. Measured insolation data and recorded load demand data for typical domestic appliances are used in this study to analyze ramp rates present. The ramp rates are then used to determine the range of energy storage ramp rate and delay time required to maintain the microgrid voltage within the standardized range of 1pu±5%. From the recorded data it has been observed that PV power can be sampled from at least 1-second intervals without losing important information. The 1 second averaged ramp rates obtained from the insolation data measurements have been found to have the highest value of 0.12pu/sec. However, this ramp rate increases to 0.3pu/sec when the allowable microgrid voltage band is narrow (1pu±5%). These insolation ramp rates are very low compared to the ramp rates of typical loads that can be connected to a microgrid. This means that, if the energy storage system is specified to meet the load ramp rate requirements, it will be able to respond to the fluctuating PV power. The results obtained from the simulations confirm that energy storage system ramp rate plays an important role in the stability of a standalone microgrid. The minimum allowable energy storage ramp rate was found to be 8.15pu/sec for load transients with a ramp time of 20ms. This value is 28 times the energy storage ramp rate required to cancel out insolation fluctuations. This further confirms that energy storage system ramp rates must be specified using the load demand data. The maximum allowable delay time was also found to be 0.53s to maintain the microgrid voltage within the standardized range of 1pu±5%. This delay time is applicable when canceling out only the insolation fluctuations. To cancel out load transient power fluctuations, there should be no delay time.