Area: PV Systems Including BOS Components

ENERGY MANAGEMENT CONTROLLER FOR PHOTOVOLTAIC CHARGING STATION (PV-CS) IN ELECTRIC VEHICLE APPLICATION

Ayda Esfandyari¹, Brian Norton², Michael Conlon³, Sarah J. McCormack⁴

¹,²,³Dublin Energy Lab, School of Electrical Engineering, Dublin Institute of Technology, Ireland, Ayda.esfandyari@dit.ie, Brian.norton@dit.ie, Michael.conlon@dit.ie

⁴Dept of Civil, Structural and Environmental Engineering, Trinity College Dublin, Ireland, Mccorms1@tcd.ie

Battery Electric Vehicles (BEVs) have been recognised as a viable solution to limit the level of CO₂ emissions and increase energy security. Due to the substantial decline in the levelised cost of electricity and feed-in-tariffs for PV systems, there has been considerable interest in promoting localized consumption of solar generated energy. This is mainly referred to as self-consumption. When considering the intermittent nature of solar energy as a resource, an approach to increase self-consumption and reliability is to integrate a Battery Energy Storage System (BESS) as part of the overall system design. Dublin Institute of Technology (DIT) has recognised the viability of this design solution; with its recent deployment of 10.5 kW, BESS based PV-CS. The charging point is utilized to provide for the demand requirements of the two campus BEV buggies (BEVs), where each vehicle has 13.76 kWh battery capacity. Depending on the load demand profile, LEVs can be charged through an individual or combination of options: direct PV output, discharge of the PV stored energy from BESS unit and/or the grid, while the surplus generation is used to recharge the BESS or is fed into the grid. The objective of this work is to simulate a heuristic Energy Manager System (EMS) controller, where the relationship and the power dispatch flow between the outputs of different energy management parameters are investigated. The methodology adopted for formulating the control logic prioritized the AC coupled target components into three priority classes, load (priority-1); BESS (priority-2) and grid (priority-3). The MATLAB logic controller receives the daily modular load demand and solar generation data as inputs. With reference to priority-1, the load served directly via PV generation at all presented times, which is indicated as (P_PV.Load). If the PV power was higher than the load, the injected surplus energy (ΔDifference>0) was utilised to charge the BESS unit (P_PV.BESS). The charging would stop once the specified technical inequality constraints of BESS such as; maximum permitted power input pulse and/or maximum State of Charge (SOC) threshold was reached. In this case, the remaining ΔDifference would feed back into the grid (P_PV.Grid). As soon as the PV power became lower than the load, (i.e. ΔDifference < 0), the BESS would switch to its discharge mode of operation to serve the load (P_BESS.Load). Once again, this condition was maintained until BESS reached its lower inequality constraints and hence, maximum permitted power output pulse and/or Depth of Discharge (DOD) threshold. In any of the aforementioned steps when ΔDifference = 0, the power from the conventional grid could be utilized as the back-up to accommodate for the shortfall of the power input to the load (P_Grid_Load). The algorithm assumed that load and grid were not responsive to recharge the BESS unit. Moreover, the PV output signal was never above the nominal generation limit. Two energy-based metrics of assessment, i.e., ratio of Self-Consumption (S-C) and Self-Sufficiency (S-S), were exploited to observe and compare the performance of PV-CS. The simulations allowed for calculating the two metrics, while looking at the energy distribution over the designated summer and winter period. The results from the heuristic simulation further compared with the outcome obtained from commercial SMA controller as well as the previously designed system model in TRANsient SYstem Simulation (TRNSYS). In order to benchmark the comparison process as well as to observe and justify the error differences, statistical error measurement techniques such as Mean Absolute Error (MAE) and Percentage Mean Error (PME) were estimated.