Phase-wise enhanced voltage support from electric vehicles in a Danish low-voltage distribution grid

High deployment of electric vehicles (EVs) imposes great challenges for the distribution grids, especially in unbalanced systems with notable voltage variations which detrimentally affect security of supply. On the other hand, with development of Vehicle-to-Grid technology, EVs may be able to provide numerous services for grid support, e.g., voltage control. Implemented electronic equipment will allow them to exchange reactive power for autonomous voltage support without communicating with the distribution system operator or influencing the available active power for primary transportation function. This paper proposes a voltage dependent EV reactive power control and quantifies its impact on a real Danish low-voltage grid. The observed network is a heavily unbalanced three-phase four-wire grid modeled in Matlab SimPowerSystems based on real hourly measurement data. Simulations are performed in order to evaluate phase-to-neutral voltage support benefits as well as to address neutral-to-ground values, active power losses and the unbalances at the same time. The analysis shows that reactive power support both raises minimum phase-to-neutral voltage magnitudes and improves voltage dispersion while the energy losses are not notably increased. Further on, since the control is voltage dependent, provided reactive power is unequal among the phases leading to greater support on heavily loaded phases and decreased unbalances caused by residential consumption. Hence, implementation of such a phase-wise enhanced voltage support could defer the need for grid reinforcement in case of large EV penetration rates, especially in highly unbalanced networks.

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