Electric Vehicles Integration in the Electric Power System with Intermittent Energy Sources - The Charge/Discharge infrastructure - DTU Orbit (16/12/2018)

The replacement of conventional fuelled vehicles with electric vehicles (EVs) is going to increase in the coming years, following the trend seen for renewable energy sources (RES), as photovoltaic (PV) and wind power. In this scenario, the electric power systems in Europe are going to accommodate increased levels of non-dispatchable and fluctuating energy sources, as well as additional power demand due to EV charging. If the charging of EVs can be intelligently managed, several advantages can be offered to the power system. How useful coordinated EV charging can be, in combination with RES, is answered in this research work. Two real cases are addressed:

- the EV load coordination for power fluctuations due to wind power, in the Danish power system;
- the EV load coordination for the power fluctuations due to Photovoltaic (PV) in low voltage grids, in several European countries.

The research work starts with the definition of EV requirements for enabling a bidirectional power exchange with the grid. A set of monitoring and control requirements are defined to achieve EV coordination. The validation of the defined requirements is performed with a full-scale EV test bed made of real EV components such as a lithiumion battery pack, a battery management system and charging/discharging units.

The second part of the research exploits the use of EV load coordination to facilitate the integration of wind power in the Danish power system. A proof of concept of regulating power reserves is realized, using the target power requests from the Danish Transmission System Operator (ENERGINET.DK), valid as the control signal for the EVs. The EV coordination is realized under the control framework of a Virtual Power Plant. The tests performed show that an EV can respond according to the time plan and the power levels needed. Furthermore, during EV coordination, a number of nonlinearities and battery ageing issues should be taken into account, to ensure a correct EV coordination and to preserve the EV battery lifetime.

The third part of this research exploits the use of EV load coordination as an energy storage solution to facilitate PV integration in LV distribution grids. In this context, the storage capabilities of EV charging stations are analyzed. Two concepts of stations are investigated: public charging station, to accommodate the parallel charging of EVs at public locations, and private charging stations at private homes. The coordination of EV load of public or private charging stations creates benefits in feeders with PV. A method based on voltage sensitivity analysis is proposed to evaluate the influence of EV load coordination at different locations in the grid. Time-series simulations and a proof of concept prove the usefulness of coordinating the load from EV stations in LV feeders with PV.

As a general conclusion, it is observed how important the role of EV load coordination can be, in coping with the fluctuations of renewable power sources at different power system levels.

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy
Contributors: Marra, F., Larsen, E., Træholt, C.
Number of pages: 173
Publication date: 2013

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English
Electronic versions: PhD_thesis_final_.PDF
Research output: Research › Ph.D. thesis – Annual report year: 2013