Energy Management System of a residential Microgrid with Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G) energy services

Mohamed Saâd EL HARRAB
Centre de Gestion Scientifique (CGS), UMR CNRS i^3 9217, MINES ParisTech, PSL Research University
Mohamed-Saad.El_Harrab@mines-paristech.fr

Michel NAKHLA
Centre de Gestion Scientifique (CGS), UMR CNRS i^3 9217, MINES ParisTech, PSL Research University
Michel.Nakhla@mines-paristech.fr

Overview

Decarbonization calls for a deep transformation of global energy systems. This mutation is supported by an increase of renewables penetration in the energy mix. Though, as they are intermittent and non-dispatchable, renewable energy sources pose various challenges. Therefore, the evolution of Smart Grid (SG) paradigm is expected to come with the plug-and-play integration of many new components, among them Microgrid (MG) and Plug-in Electric Vehicle (PEV).

On the one hand, MG is defined as a small-scale localized power grid which can either work singly or compete with nearby main electrical grid. The emerge of this new subsystem raises multiple energy management challenges. Using an Energy Management System (EMS), MG cover both supply and demand side management to realize an economical and secure operation control, while satisfying the energy system constraints.

On the other hand, the introduction of the PEVs as an alternative to fossil fuel vehicles can play a major role in smoothing out the intermittent power supply locally. As mobile energy storage systems, PEVs can deliver energy back to power grids and allow different discharging scenarios generally known as Vehicle-to-Anything (V2X). This activity gathers various generation modes such as Vehicle-to-Load (V2L), Vehicle-to-Home (V2H), Vehicle-to-Building (V2B) and Vehicle-to-Grid (V2G).

The objective of this work is to design and develop an EMS to intelligently manage the operations of a residential MG and EV charging station enabling Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G) energy services.

Methods

For this work, we consider a residential grid-connected MG equipped with a photovoltaic (PV) system as renewable energy source and a home EV charging station for 2-way charging and power supply. Based on Stochastic Optimization, Machine Learning approaches and Game Theory, we investigate different scenarios of the MG optimization considering various uncertainties (economical, operational) and constraints (power balance, generation, technical …). Taking into consideration electricity prices, PEV driver's behaviour and the forecast of load curve and solar irradiance, the developed EMS optimizes the scheduling and the power dispatch of the MG considering PEV charging and V2G/V2H energy services.

Results

The developed EMS minimizes the total cost of operating the residential MG and the PEV charging. The main results of the optimization are two-fold. First, the model shows that energy cost savings are achieved while increasing self-consumption. However, the introduction of V2G/V2H impacts the PEV batteries lifetime.

Conclusions

One of the most promising options to increase distributed energy production while reducing the energy cost for households relies on the implementation of V2G and V2H energy services. The synergy between PEV batteries and the intermittency of renewable production play a major role in smoothing out peaks in consumption.

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