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OPTIMIZATION OF BATTERY SWAPPING STATIONS WITH HETEROGENEITY, CHARGING DEGRADATION AND PV-OPTION

Nickolas Gueller[1*]
Rafael Martinelli[1*]
Bruno Fanzeres[1*]
Daniel Louzada[1*]

ABSTRACT

Greenhouse gas emissions-related issues have been extensively discussed in the past years, with over 70 countries already committed to a carbon-neutral economy by 2050. The electrification of transportation modals has increased following these goals, where Electric Vehicles (EVs) are starting to take Internal Combustion Engine Vehicles (ICEV) market share all over the globe. Besides the particular complexity in comparing EVs and ICEVs, challenges involving the nature of EVs and their integration with cities, such as the lack of public locals for charging, are also critical and interfere with their development. In this context, this work aims at studying the problem of a Battery Swapping Station (BSS), a structure where the EVs users swap their depleted batteries for fully or partially charged ones. In order to simulate the BSS daily operations and battery charging schedule, a novel Mixed Integer Linear Programming (MILP) model is proposed, taking into account battery heterogeneity, the use of local photovoltaic (PV) production, and battery degradation based on charging profile. A collection of BSS operation metrics are designed to evaluate the solution quality of the proposed scheduling model. A numerical experiment comprising four case studies based on real data from the US power and transportation systems is presented, with insights and analyses on the PV and grid power use, as well as a BSS financial comparison against close-related benchmark scheduling approaches, together with sensitivity analyses on BSS sizing plan and costumers service. Results highlight the importance of battery degradation in the optimization model, since its consideration as an operational cost brought a reduction of 16%.

Keywords: Battery Swapping Station; Electric Vehicles; Photovoltaic Power Production; Mixed-Integer Linear Programs; Distributed Energy Sources; Battery Heterogeneity.

[1] Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio)
*nickolas@aluno.puc-rio.br; martinelli@puc-rio.br; bruno.santos@puc-rio.br; louzada@puc-rio.br