INTERNATIONAL TRANSACTIONS ON ELECTRICAL ENERGY SYSTEMS
Int. Trans. Electr. Energ. Syst. 2016; **26**:1287–1302
Published online 21 September 2015 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/etep.2134

Energy loss minimization using PHEVs as distributed active and reactive power resources: a convex quadratic local optimal solution

Hamed Nafisi*,†, Hossein Askarian Abyaneh and Mehrdad Abedi

Amirkabir University of Technology (Tehran Polytechnic), Department of Electrical Engineering, Tehran, Iran

SUMMARY

Plug-in hybrid electric vehicles (PHEVs) are becoming more prevalent day by day. The batteries of these electric vehicles may be charged from a standard outlet at home. These extra electrical loads have several impacts on distribution networks, e.g. network energy loss. This paper presents a convex quadratic local optimal solution, instead of non-convex global optimal approach, to minimize the energy loss of distribution system with the different penetration levels of PHEVs. In this paper, it is assumed that vehicle owners can charge their vehicles either at workplace or at home. Furthermore, daily needed energy of PHEVs is simulated based on stochastic modeling of PHEV owners' behavior at any time. Moreover, in this paper it is supposed that PHEVs can be used as reactive power resources in vehicle to grid (V2G) operation mode. The proposed methodology is applied to a realistic distribution network. The results show that network energy loss may be remarkably increases, as the penetration of PHEVs increases without smart charging strategy. Managed and smart charging of PHEVs is needed to minimize the extent of network energy loss. As revealed by the results, smart charging of PHEVs with consideration of V2G operation mode in conjunction with charging at workplace may have the most effect on the network energy loss reduction. Copyright © 2015 John Wiley & Sons, Ltd.

KEY WORDS: Plug-in hybrid electric vehicle (PHEV); energy loss minimization; managed charging

1. INTRODUCTION

The swift technological advances in the automotive sector, in conjunction with the increase of oil prices and the growing environmental concerns, have triggered the appearance of electric vehicles (EVs) with diversified energy sources. This is the case of plug-in electric vehicles (PEVs). There are basically two types of EVs: pure battery electric vehicles (BEVs), which solely work with batteries as electric power source; or plug-in hybrid electric vehicles (PHEVs), which essentially work with a combination of two power sources, i.e. batteries and gasoline. The latter are an extended version of current hybrid electric vehicles (HEVs) including a battery with larger autonomy and able to be charged from a standard outlet at home [1,2].

The PHEVs consume a large amount of electrical energy. This demand of electrical energy will result in large and distasteful peaks in the energy consumption [3]. Thus, charging these vehicles from home outlets has impacts on the distribution system. The charging impacts of PHEVs on the power distribution networks have been introduced in the literature and have been widely investigated [1,4–6]. These impacts are generally categorized into two classes: effects on distribution system equipment, which include effects on transformers [7], cables [8], circuit breakers, and fuses [8], and general effects on distribution system characteristics, which include harmonics [8], power quality [9], load profile [10], and power loss [5].

In the literature, significant effort has been devoted to the optimal PHEV charging and discharging [2,4,5,11–16]. On the other hand, many research efforts are focused on the infrastructures and architectures of smart charging [17]. The focus in this paper lies on both of them.

*Correspondence to: Hamed Nafisi, Amirkabir University of Technology (Tehran Polytechnic), Department of Electrical Engineering, Tehran, Iran.
†E-mail: nafisi@aut.ac.ir