Voltage Profile and Power Factor Improvement in PHEV Charging Station Using a Probabilistic Model and Flywheel

Iman Niazazari, Hossein Askarian Abyaneh, Mohammad Javad Farah, Farhad Safaei, Hamed Nafisi
Department of Electrical Engineering
Amirkabir University of Technology (Tehran Polytechnic)
Tehran, Iran

Abstract—**This paper investigates PHEVs effect on a distributed network while they charge in charging stations. In this paper, voltage profile and power factor improvement are made in the presence of PHEV. PHEV Charge modeling parameters such as battery capacity, PHEV daily traveled distance and PHEV entrance time to charging stations all are probabilistic. Thus, a mathematical probabilistic model for PHEV charging seems to be necessary. In this paper PHEVs charging effect on substations at which PHEV charging stations are located, will be seen. To solve the increasing load demand issue, an objective function with a modified probabilistic PHEV modeling has been developed to acquire the suitable storage equipment to improve voltage profile and power factor of the system. All simulations have been conducted via GAMS software.**

Keywords—Charging Station; Charging Power; PHEV; Battery Capacity

I. INTRODUCTION

Vehicle industry has improved not only the human life ease, but also the world economy. Every year over 10 million vehicles are sold all over the world. Yet, almost all of vehicles use induction engines which cause huge issues such as air pollution, earth warming and oil depletion.

According to [1], greenhouse gas generation ranking by United States transport system is in second place. The world average temperature has been increased by 0.6 Celsius degrees over the past 50 years [2]. Oil exploration has been decreased from 1981 which led to higher oil cost and lower oil production [3]. If PHEVs are meant to be used for long distances, charging PHEVs in high powers would be desirable. In this condition, it is necessary to charge PHEV in some minutes instead of some hours [4].

When PHEVs are charged by fast PHEV charging station, each PHEV consumes a huge power from the network (about 100 times more than charging in house). This huge power has adverse effects on the network in large scales. In other words, the major problem is that while a PHEV is charged quickly, the demand load increases largely. The problem is that this huge power should be consumed from the network in some minutes. This matter has harmful effects on both voltage profile and equipment. Therefore, some energy storage equipment such as ultra-capacitor and flywheel in PHEV charge stations are used. The energy storage equipment stores the energy in low energy demand durations, and will inject the stored energy to the network in high energy demand durations. In [5-7] impact of electric vehicles on power distribution networks has been investigated. In [8-10], PHEV charging strategies in order to minimize distribution system losses has been proposed. In [11], a novel load management solution for coordinating PEVs charging in smart grid to improve voltage profile and minimize power losses has been proposed. In [12], smart load management of PHEVs in charging station for peak shaving and loss minimization considering voltage regulation has been conducted.

In this paper an objective function based on a probabilistic model has been developed to optimize the voltage profile and power factor of the system by acquiring suitable storage equipment. In other words, this paper deploys a probabilistic model including parameters such as battery capacity, daily traveled distance and distribution of arrival time of PHEVs to charging stations. Moreover, the number of charging in the charging stations over a day is considered as an additional parameter in finding daily required charging energy which is one of the novelties of this paper.

The rest of this paper is organized as follows: section 2 develops a probabilistic model of the load and PHEV charging. In section 3 the objectives function and problem constraints have been defined. The simulation results have been illustrated in section 4. Finally, in section 5 the conclusion has been presented.

II. LOAD AND PHEV CHARGE MODELING

In order to see the effects of PHEV charging on the network, it is necessary to find base load profile and PHEV charging profile, separately and add these two profiles together. The added profile will be then used in load flow formulation and the proposed objective function. In this section at first a concise description of the base load development is presented and after that a comprehensive PHEV charge modeling is presented.

A. Load Modeling

In [13], the yearly peak load data for all the substations are given. In order to analyze the system, it is needed to have