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Mobile Power Infrastructure Planning and Operational Management for Smart City Applications

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Abstract

The paper presents new strategies and algorithms for future mobile power infrastructure planning and operational management in smart cities. The efforts have been made to develop a resilient Electric Vehicle (EV) infrastructure for smart city applications. The goal of this work is to maximize the profit of utility and EV owners participating in real-time smart city energy market subjected to numerous techno-economic constraints of the EVs and power distribution system. For effective real-time applications, the knowledge of artificial intelligence and internet of things (IoT) are used in the proposed model. In order to validate the proposed model for smart city applications, IEEE 33-bus radial distribution network is adopted as a small city power network. The simulation results of proposed model are found to be encouraging when it is compared with the case in which conventional strategies are used.

Keywords: Artificial intelligence; distributed resources; electric vehicle; internet of things; smart city.

1. Introduction

The growing urbanizations, global energy crisis, greenhouse gases emission, depleting conventional resources etc. has led to the vision of Smart Cities (SCs) deployment. Currently, cities are the major energy consumers and greenhouse gas emitters which significantly affected the climate and energy security [1]. The key motivation behind SC deployment may be the optimal utilization of available resources which are necessary for survival of the society. However, the definition of SCs is not yet standardized due to the broad vision of smart city deployments [2].

The common scopes of SC deployment may be to increase the living standard of inhabitants by facilitating with basic needs such as electricity, water, gas, transportation, information and communication, traffic and all types of pollution control, basic medical services, etc. Among these, the smart electricity infrastructure planning and

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management may play a vital role in SC deployment which may include the optimal management of distributed resources such as Distributed Generations (DGs), shunt capacitors, battery energy storage, Electric Vehicles (EVs) and demand response programs. The optimal planning and management of these resources may provide a wide range of benefits for utility and consumer [3], which may include minimized power/energy loss, emission and operating cost, improved voltage profile, stability and reliability etc.

In literature, various optimization models have been investigated for optimal planning and operational management of distributed energy resources to achieve various techno-economic goals for SC applications. In [4], a SC transportation network architecture based on supercapacitor-powered electric buses is developed to improve the grid operation efficiency and to reduce the oil consumption of transportation sector. A particle swarm optimization based EV charging strategy is proposed in [5] to minimize the operating cost of system while meeting the EV owner's requirements. In [6-7], frameworks are developed for realization of SC vision through Internet of Things (IoTs), the frameworks are exploiting the most advanced communication technologies to provide value added administration for SC inhabitants. The statistical behavior of EV charging and effect of DG mix are studied in [8] to reduce the emission in Italian cities. In [9], a hierarchy of decision-making strategy is proposed for energy management applications in SCs. In [10], stochastic dynamic model for optimal charging of electric vehicles is proposed. A multi-objective approach for minimizing load variance and charging cost of electric vehicles is presented in [11]. The discussed and recent literature witnessed the growing interest and importance of energy efficient applications in SC deployment.

In this paper, mobile power infrastructure model is developed for SC applications to achieve various techno-economic benefits. The work introduces few new strategies and algorithms for effective planning and real-time management of EV and distribution system infrastructure. An optimization framework is developed to maximize the techno-economic benefits of EV owners and utilities comprises of 24-hours activities of distribution system and EVs using artificial intelligence and IoTs. In order to validate the proposed model, IEEE 33-bus distribution network is considered as a smart city distribution network. The simulation results of proposed strategy are compared with that of the case in which such strategies are absent. The comparison results show the superiority of the proposed model.

2. Proposed Mobile Power Infrastructure Model for Smart City Applications

The future rapid growth of EVs may raise many challenges and issues for future distribution system operators as it will introduce more uncertainties in the system. In order to alleviate some of the issues, optimization models and strategies may play a vital role in the future mobile power infrastructure planning and management. The proposed mobile power infrastructure planning and management model based on artificial intelligence and IoTs is shown in Fig. 1.

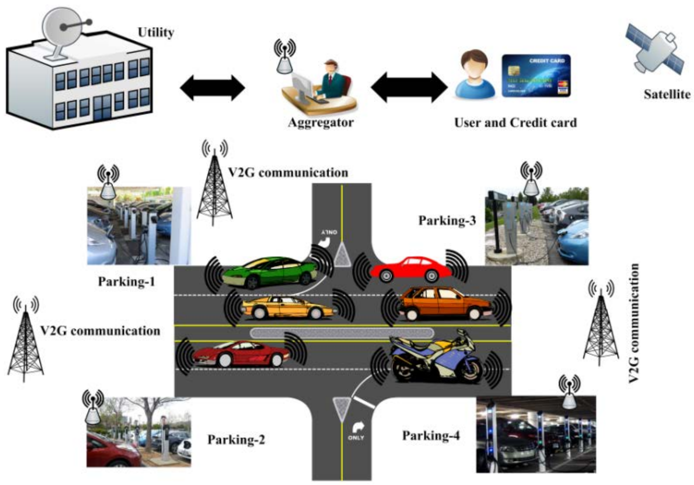

Fig. 1 Basic structure of proposed mobile power infrastructure planning and operational management in smart cities

It may be observed that majority of professionals are found to be in commercial and industrial areas in daytime. In proposed work, each vehicle is assumed to be associated with unique smart ID and IoT chip with the information