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Combinatorial optimization for electric vehicles management

Nora Touati-Moungla and Vincent Jost
LIX, Ecole Polytechnique, 91128 Palaiseau Cedex, France
Phone: +33 1 69 33 40 92, Fax: +33 1 69 33 40 49
E-mail: touati@lix.polytechnique.fr, vincent.jost@lix.polytechnique.fr.

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Abstract

Growing concerns about environmental quality of cities are calling for sustainable road transportation technologies. Electric Vehicles (EV), for public and private transport, can contribute significantly to the lowering of the current pollution levels. However, the EV use is currently facing several weaknesses among which are: limited driving range, high cost and overall limited efficiency. This paper aims at specifying some key contributions of combinatorial optimization for an efficient electric vehicles management.

Electric vehicles management, Routing problem, Facility location, Vehicles redistribution.

1 Introduction

Distribution and transportation systems have been intensively studied in the operations research literature [17]. 73% of all oil consumed is Europe is used in transport and road transport accounts for 25% of CO2 emissions of the overall transport activity. From both an environmental and energy points of view, the introduction of EV should be a first priority for the reduction of primary energy consumption.

Although higher concerns are the opportunities EV provided in terms of efficiency and flexibility in the use of energy, the EV use however is currently facing several weaknesses among which are: (1) The low energy density of batteries compared to the fuel of combustion engined vehicles, (2) EV often have long recharge times compared to the relatively fast process of refueling a tank and (3) The scarcity of public charging stations.

Electric Vehicles Management (EVM) is a relatively recent problem, its purpose is to expedite the establishment of a costumer convenient, cost-effective, EV infrastructure. Inspite the relevance of the problem, a few small research communities in this field work on some aspects of this problem. In this work, we discuss some important issues of this problem and show how CO tools can be used for solving some challenging subproblems.

Routing of EV is a major aspect of EVM, it consists of designing routes for maximizing the autonomy of vehicles, efficient EV routing plays a major role for encouraging EV use. We discuss in this paper this problem, we present a mathematical formulation of the *energy shortest path problem* and the *energy routing problem* and we expose some relationships between these problems and other well-known routing problems.

Limited driving distance between battery charges is a fundamental obstacle to broad consumer adoption of EV. In order to eliminate this fundamental disadvantage and increase consumer acceptance and usage of EV, a sufficient number of charge stations is required. The objective is to establish a charging network that is conveniently placed in familiar places to meet consumers needs. The localization of EV charge stations is known in CO field as the *facility location problem*, we define here this problem and we expose some models proposed in the literature.

The Self-Service Electric Vehicles (SS_EV) is a key concept for developing urban clean mobility. The "free" use of EV would cause either overflow or shortage of vehicles at some stations at some times of the day. This system require a redistribution of EV over the stations, this problem is generally modeled as a special *pick-up and delivery problem*, we discuss in this paper some of its characteristics and resolution meth-