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Editorial

Energy in Smart Urban Transportation with Systemic Use of Electric Vehicles

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1. Introduction

In the progressive development of Electric Vehicles (EVs) and the transformation of transport towards electromobility and decarbonization of cities, many different problems are being faced related to energy management in transport in smart cities. In order to increase the scientific interest of researchers from various fields in the problems of using EVs in the energy networks of smart cities that share their energy resources with renewable energy sources and energy storage, this Special Issue of Energies entitled "Energy in Smart Urban Transportation with Systemic Use of Electric Vehicles" was prepared, consisting of six research papers. In this Special Issue, papers were collected, the subjects of which cover advanced problems in the design, implementation, and operation of EVs. When selecting the papers, the main consideration was the key issues concerning the energy efficiency of the operation of such vehicles, both in terms of optimizing routes in the smart urban transport network [1], as well as taking into account the installation of batteries in vehicles [2], topologies for fuel cells and energy-management strategies [3], intelligent battery systems [4], the operation of a microgrid network with EVs [5], and the use of EVs in power systems with renewable energy resources [6].

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2. A Short Review of the Contributions in This Special Issue

Brief summaries of the six selected papers belonging to this Special Issue "Energies" titled "Energy in Smart Urban Transportation with Systemic Use of Electric Vehicles" are included in the next subsections.

2.1. Problem of Estimation of Energy Expenditure of Low-Emission Fleets in Urban Service Companies

An analysis of the literature highlighted that the application of Electric Vehicles (EVs) in urban service enterprises, e.g., courier companies or municipal enterprises and companies collecting waste from inhabitants, is still a great challenge for researchers. Customers are located in different areas of cities, so tasks in these enterprises consist in vehicle routes between individual customers and a collective point—described in terms of the problems of VRP (Vehicle Routing Problem) with Pick-Up and Delivery—in which vehicles visit individual customers, pick up or deliver cargo, and return to a collection point. This research work [1] proposes a new approach for EV routing in urban service enterprises in the context of the Vehicle Routing Problem (VRP) focused on determining the energy expenditure of EV fleets by applying a hybrid heuristic algorithm. The authors present a hybrid algorithm based on an ant colony algorithm and a genetic algorithm to solve the problem of estimating the energy expenditure of low-emission fleets in urban service companies due to the ecological safety of city inhabitants. The energy expenditure from the use of Electric Vehicles was defined as a criterion function with the maximum range or battery charging time as the boundary conditions. In the summary of the paper [1], the authors emphasize, inter alia, that complex decision problems, which is the problem discussed in the article, heuristic algorithms generate suboptimal solutions, i.e., near-optimal solutions. This is mainly due to the probabilistic nature of the algorithms and the research in a limited space of acceptable solutions. Such conditions make it impossible to determine the global optimum for complex decision problems. Moreover, there is also an NP-hard problem with many local minimums in the discussed issues. Therefore, the authors also point out that it is necessary to use a set of mechanisms that prevent the premature convergence of both algorithms to the first local minimum encountered. For this purpose, the authors proposed the following mechanisms: linear scaling in the roulette method in the genetic algorithm and cyclic updating the pheromone trail at the beginning of each iteration in the ant algorithm. Considering the results presented in [1], the authors conclude that the combination of the two presented heuristic algorithms with different operations may be an effective tool for determining the energy expenditure of vehicles in service companies.

2.2. Problem of the Design Procedure for the Optimal Installation of Battery Systems in Battery EVs

Setting up a design procedure for the optimal installation of battery systems in battery Electric Vehicles (BEVs) was presented in this research [2]. The authors propose simultaneously optimizing two vehicle parameters—the battery pack weight and capacity—taking into account, inter alia, such critical factors as the battery cell type, geometry, size, number of cells, location, and space between cells and modules. The objective of this analysis is to increase the battery capacity while decreasing the overall vehicle weight. Towards this aim, various cell formats and geometries were investigated, and considerations about their arrangement within the module and battery pack were made. Lithium-ion batteries were chosen in the study, as they are increasingly becoming the best choice for automotive applications due to their higher specific energy density. Different pack-filling strategies were developed, depending on the cell format, and the best solutions were identified. This paper shall thus be considered as a basis study to be further investigated, and the presented case study can inspire industrial processes where the conversion design is deployed from the very beginning of the entire vehicle design task in such a way as to promote more effective integration of the main powertrain devices and electric components.

2.3. Topology Problems for Fuel-Cell EVs and Energy-Management Strategies

In the last decade, many scientific and research works have indicated that one of the cleanest and most efficient fuels is hydrogen. Moreover, in electrochemical processes, hydrogen can be converted into electricity in the fuel-cell system, which makes it much more efficient than the conversion of conventional fuels into mechanical energy. In order to achieve viable Fuel Cell Electric Vehicles (FCEVs), with an opening to the market for marketing purposes by the manufacturers of the automotive industry, the main challenge is to develop a control strategy for energy management—these strategies lead to the improvement in the performances from the points of view of energy and the reliability of the components. This research [3] compares the latest proposed topologies for Fuel Cell Electric Vehicles and reveals the new technologies and DC/DC converters involved in generating up-to-date information for researchers and developers interested in this specialized field. New energy-management strategies (EMS) were compared with reference strategies, taking into account those performance indicators that are a major challenge in car design, including energy efficiency, hydrogen consumption, and the degradation of the subsystems involved. The research took into account the advantages and disadvantages of three types of strategies, i.e., rule-based strategies, optimization-based strategies (real-time optimization and global optimization), and learning-based strategies. The research included, inter alia, the following communicative configurations: vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), connected and automated vehicles (CAV), vehicle-to-everything (V2X) (a technology that integrates all the vehicle connection technologies, and vehicle-to-grid (V2G) as the most developed commercial topology.

2.4. Problem of Intelligent Battery Systems–Characteristics and Implementation

The key element of the drive train of Battery Electric Vehicles (BEVs) is energy storage, commonly realized by a rechargeable battery system. Intelligent Battery Systems (IBSs), as a new technological advancement, represent a promising but also challenging approach to significantly improving the reliability, safety, and efficiency of BEVs. This research [4] presents a solid literature review (over 80 pages based on over 600 literature items) on the characteristics and implementation of IBSs, whose important features are the accurate and reliable determination of the states of individual cells and the ability to control the current of each cell through reconfiguration, including sensors, battery topologies and management, switching elements, communication architecture, and the impact on the single cell. Such battery systems enable high-level functions such as fault diagnosis, multi-criteria balancing strategies, multi-level inverters, and hybrid energy storage systems. This review focuses on approaches that are applicable not only at the laboratory level but also at the BEV level. In addition, general health-estimation methods are being reviewed to meet the challenges of automotive applications such as estimating the state of a single cell in a system. Moreover, aspects of the implementation and reconfiguration of sensor technology have been specifically considered in this review. Based on the variety of approaches, the authors specify those battery systems as intelligent that incorporate following systems: additional sensors or advanced monitoring functions on the cell level and/or actuators such as switches to modify the reversibly of the system's topology. The authors of this research review [4] concluded that, as a new technology, IBS is at a fairly early stage of development and that significant improvements should be made to technological maturity. Despite the existing challenges, IBSs have the potential to improve the battery systems of BEVs and provide new advanced solutions to the many problems encountered with conventional battery systems.

2.5. Three-Phase Microgrid-Management Problems with EVs

Various technical and economic benefits, such as minimizing power losses, improving the voltage profile, and reducing energy costs annually, are the aim of the optimal integration of renewable and non-renewable distributed generation (DG) in distribution grids. Microgrids are solutions that consist of various generation and consumption units in a smart grid configuration, enabling the communication of all elements and ensuring better system performance; can provide appropriate strategies for controlling and managing power sources; and can improve the power quality and reliability of the electrical system. It turns out that there are problems with a larger number of EV users connected to the grid, which can cause high peak demand during certain periods of the day, and furthermore, the integration of EVs can cause some harmful effects on the power grid, such as phase unbalance, harmonic distortions, overloading components, and an increase in power loss. Considering the spread of EV usage for ancillary services and the issue of the low power factor in current electrical grids, this research [5] proposes an improved control strategy for microgrid management: a three-phase microgrid management composed of a photovoltaic (PV) array, dynamic loads, and an Electric Vehicle (EV) parking lot. This strategy takes into account Multi-Objective Optimization (MOO) with different operating modes and aims to achieve both power-factor regulation and economic battery charging. The control provides three operation modes (Charging Mode, Power Factor Regulation Mode, and Standard Mode) to ensure the proper operation of the microgrid power factor, maintaining it above the reference value while attending to the EV users' requirements such as attaining the desired state of charge (SOC) at the instant of disconnection. The authors of the study [5] emphasize that the Multi-Objective Optimization (MOO) strategy can provide economic benefits for networks with a high PV share and that the proposed control strategy can be applied to various systems consisting mainly of EV parking and DG units, as well as to other systems energy storage (ESS) such as stationary batteries.

2.6. The Problem of Maximizing the Integration of Renewable Energy Resources with EVs

This study [6] presents a case study of a program for energy system transition for the Portuguese Porto Santo Island. This case study characterizes a possible future scenario for the island's power system, relying predominantly on Renewable Energy Resources (RES)—wind and solar energies. To maximize the integration of RES, an innovative solution is proposed that utilizes the following resources: (i) the deployment of grid-scale Energy Storage Systems (ESS), consisting of Li-ion batteries and Compressed Air Energy Storage technology (CAES); (ii) the flexible use of electricity demand associated with the water supply sector by optimum scheduling of the Reverse Osmosis Desalination (ROD) plant operation; and (iii) the flexibility that a large number of Electric Vehicles (EVs) could provide under the Vehicle-to-Grid (V2G) concept. To evaluate the proposed integrated management of resources, each source was characterized considering the operational limitations. The supply/demand equation was regarded as a hard constraint in the model. Then, the model was optimized using a genetic algorithm for the simulation period: three consecutive days (72 h) from July, August, and December were selected to cover the seasonality variations associated with the RES's availability and changes in the demand profile. Although this work did not discuss the EV's participation in the energy market, it demonstrated the benefits of a coordinated smart V2G/G2V concept from the grid operator's perspective. One of obtained results revealed that the high penetration of EVs optimizing the integrated management of resources could lower the frequency of curtailment events and reduce the dependence on fossil fuels to nearly zero. Optimizing the time and power (demand/supply) through a purposeful EVs charging/discharging procedure might be the most beneficial and efficient strategy to further the decarbonization paradigm on the island—as a case study—since transport electrification would contribute to reduced CO_2 emissions, increased energy efficiency, better air quality, and the integration of different energy sectors.

3. Conclusions and Future Works

The papers in this Special Issue of Energies titled "Energy in Smart Urban Transportation with Systemic Use of Electric Vehicles" highlight a variety of problems related to the operation of Electric Vehicles and the traction of battery-charging infrastructure dedicated to these cars. In particular, it is about such a charging infrastructure for these EVs that effectively connects it during the charging process, as well as other renewable energy sources and energy storage in a microgrid network, in order to use their shared resources with the use of sustainable management systems.

The areas of system integration of such solutions include Intelligent Transport Systems (ITSs), whose design concepts take into account the issues of appropriate functional-operational configuration [7,8] of ITS services [9].

In addition, the presented problems of using EVs also relate to the appropriate design and principles of battery operation and their topology, together with the control systems and management of charging and converting electrical energy into mechanical energy for vehicle movement, and vice versa, i.e., the use of energy recovery during vehicle inertia and braking.

The problems presented in this Special Issue of Energies are practically unnoticeable by an ordinary individual user of Electric Vehicles, because the use of EVs by individual owners is in practice associated with only two problems associated with reaching the planned destination: (i) the problem of controlling and maintaining a sufficient level of battery charge of the EV to reach the destination and (ii) the problem of planning a route in such a way as to be within the range of the charger in case of insufficient battery charge of the EV.

Therefore, the scientific content of this Special Issue of *Energies* will certainly inspire researchers who are knowledgeable about EVs, and will also provide knowledge to average individual users of EVs. However, the studies in this Special Issue will provide scientific and research interest that may be useful in solving research and development problems of

EVs—both those presented in this Special Issue of Energies, as well as many other problems related to electromobility and decarbonization of transport.

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