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SPECIAL SECTION ON ADVANCES IN AUTOMATION AND OPTIMIZATION FOR SUSTAINABLE TRANSPORTATION AND ENERGY SYSTEMS

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Guest Editorial
Special Section on Advances in Automation and Optimization for Sustainable Transportation and Energy Systems

This special section of the IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING (T-ASE) focuses on new models, methods, and technologies for energy efficiency and sustainability in transportation and energy systems. In this section, the focus is thus on articles considering sustainable transportation, such as electric vehicles (EVs), integrated with the smart grid requirements. As guest editors, we are very pleased to present the selected 12 papers, whose topics are specifically related to optimal planning of charging stations (CSs), sustainable transportation and mobility, EVs integration in smart grids, reliability, reduction of consumption, demand response and smart grid modeling, optimal scheduling, routing and charging of fleets of EVs, as well as smart parking.

The need for attaining a significant reduction in the emissions of greenhouse gas (and, in general, pollutants) has led to the necessity of introducing cleaner and more efficient technologies for energy needs in different sectors, such as transportation, smart grids, and sustainable buildings. This trend has created new challenges for the development of models, methods, and ICT-based technologies. For example, sustainable transportation has posed attention to new possible combustibles that in turn require a re-design of the overall supply chain and a new planning framework based on the integration with energy systems and smart grids. On the other side, smart grids include renewables, microgrids, CSs, and distributed generation that require careful management of the grid and the development of demand response programs. In a not-so-futuristic vision, EVs, i.e., private cars, buses, trucks, ships, and so on, will be widely used and new technologies will be proposed for CSs, batteries, and vehicles. Moreover, EVs will act as distributed energy resources, since they can provide regulation services and power supply, thus enabling vehicle-to-grid (V2G) or vehicle-to-building (V2B) operations.

To respond to these emerging changes and needs, researchers are intensively investigating the application of automation and optimization tools and techniques to sustainable transportation and energy systems, with particular attention to the use of optimization models for location of CSs, charging operations, business models, and EVs integration in smart grids, microgrids, biomass supply chain design for biodiesel production, hydrogen production management, electrification of harbors, and electric public buses management. In particular, we observed the following major research topics in the wide area of automation and optimization for sustainable transportation and energy systems:

1) Optimal planning of CSs in smart cities through interdisciplinary approaches.
2) Sustainable transportation and mobility.
3) EVs integration in smart grids, including V2G and V2B technologies.
4) Reliability of transportation and energy systems.
5) Reduction of energy consumption.
6) Demand response in the energy market.
7) Power management in CSs and smart parking.
8) Optimal scheduling of EVs fleets and car sharing.
9) Optimal routing and charging of green vehicles.
10) Joint design of electrical and transportation networks.

The proposed special issue is an opportunity for highly qualified researchers, academicians, and practitioners to exchange new ideas and results on automation and optimization for sustainable transportation and energy systems. A high number of papers have been submitted to this special issue and all manuscripts went through a peer-review process, after which 12 contributions were selected for publication.

Not surprisingly, the papers selected for inclusion in this special issue exemplify and corroborate the aforementioned trends in the scientific research on automation and optimization for sustainable transportation and energy systems. More specifically, the included papers can be conceptually divided into the following different macro-categories.

1) Models and methods for the optimal planning and management of EVs integrated into smart grids: this class collects seven papers, including contributions from research topics a), c), f)–j).
2) Methods and approaches to improve consolidated transportation modes: this class collects five papers, including contributions from topics b), d), e), and g).

As regards topics in macro-category 1), several papers are focused on the main problems related to EVs. In particular, in [A1], Xiang *et al.* consider the routing and charging of multiple EVs and propose an event-driven pricing strategy. Through simulations, the authors demonstrate that the pro-

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posed strategy can not only alleviate the long-time queuing for EVs fast charging, but also improve the utilization rate of charging infrastructures. In addition, in [A2], Fanti *et al.* propose two methods for EVs relocation in an EV-sharing system in order to minimize the relocation costs and guarantee the high quality of the service: 1) a centralized method, where the decisions are taken by a unique decision-maker by using the complete knowledge of the system and 2) a randomized matheuristic algorithm, where decisions are taken by the stations that cooperate to solve the relocation problem. In both methods, two integer linear programming problems are formulated to minimize the relocation cost in the two considered approaches.

In some other articles, EVs are integrated with the electrical grid, the transportation network and the assessment of environmental impacts both from planning and management points of view. In [A3], De Angelis *et al.* include the electrification of the light vehicle fleet and the use of biomethane to power heavy vehicles in an integrated assessment methodology. The authors' aim is to support decision-makers to select a set of energy production scenarios, minimizing costs, impacts on air quality, and greenhouse gases emissions. In [A4], Ferro *et al.* faced planning problems, in which the decision problem is the optimal placement and sizing of CSs and the coupling of traffic and electrical networks.

In fact, a wide usage of EVs may cause technical problems to the electrical grid (i.e., instability due to intermittent distributed loads), inefficiencies in the charging process (i.e., lower power capacity and longer recharging times), long queues, and/or a bad use of CSs. A correct management of the smart grid is thus more and more important and, for this reason, multiple articles accepted in this special issue detail these topics. In [A5], Rahman *et al.* propose a new distributed real-time alternating direction method of multipliers technique to control EVs and battery storage systems (BSSs) for voltage regulation while maximizing their utility function. A continuous-domain real-time optimization and control algorithm is developed in closed form, which exchanges relevant information among the neighboring nodes through the communication network and optimizes a combined convex objective of EVs and BSSs welfare and voltage regulation with power flow equations as constraints.

Another option to alleviate the management of the electrical grid is to perform demand response programs through an aggregator that considers all production, loads, and flexibility capabilities in a certain portion of the grid. In [A6], Ojand *et al.* present a demand response scheduling model for a residential community using an energy management system aggregator that manages a set of resources, including a photovoltaic system, an energy storage system, some thermostatically controllable loads, and some EVs. The problem is formulated as a mixed-integer linear programming in which the objective is minimizing the operation and degradation costs related to the energy storage system and the EVs batteries. To mitigate the uncertainties associated with system operation, a two-level model predictive control approach integrating the Q-learning reinforcement learning model is designed. In [A7], Helmi *et al.* give specific attention to the reconfiguration of distribution networks (DNs), whose aim is to determine the optimal DN topology changing the close/open status of all available branch switches to form an admissible graph connecting network buses. A novel effective optimization framework is presented for the reconfiguration problem to minimize the overall power losses while ensuring an enhanced DN voltage profile. A multiple-step resolution procedure is then proposed, where the recent Harris Hawks optimization algorithm constitutes the core part and is compared with two related metaheuristic techniques, namely, the particle swarm optimization algorithm and the Cuckoo search algorithm.

Further papers in the special issue are focused on consolidated and widespread sustainable transportation modes, focusing attention on control and energy efficiency (macro-area 2). Two articles, in particular, are focused on railway transport. In [A8], Cavone *et al.* propose an automatic rescheduling algorithm for real-time control of railway traffic, which aims at minimizing the delays induced by a disruption and eventual disturbances, as well as the resulting cancellations of train runs and turn-backs (or short turns) and shunting of trains in stations. The real-time control approach is based on a model predictive control scheme, where the rescheduling problem is solved by mixed-integer linear programming using macroscopic and mesoscopic models. The proposed resolution algorithm combines a distributed optimization method and bi-level heuristics. In [A9], Chen *et al.* propose a novel iterative learning control scheme for high-speed trains, aiming at tracking the desired reference displacement and velocity, where the Krasowskii function is constructed to compensate for the negative influence of unknown time-varying speed delays. In [A10], Kalikatzarakis *et al.* consider another transportation mode, which considers offshore maritime operations—and in particular automated systems, referred to as marine dynamic positioning systems—capable of maintaining the position and heading of the vessel using its own propellers and thrusters to compensate exogenous disturbances, like wind, waves, and currents. Special attention is given to fuel consumption and to finding strategies that minimize the overall footprint of the vessel.

Finally, the special issue is focused on general methods and issues that can be applied transversally in many transportation systems and/or facilities for EVs. In [A11], An *et al.* consider general parking, in particular addressing the online parking-space sharing issue, while ensuring the privacy of customer parking destination locations. A novel online parking-space sharing problem is formalized as a social welfare maximization problem in a two-sided market, where parking-space providers and customers are regarded as sellers and buyers. Finally, in [A12], Zhang *et al.* focus on risk assessment and propose a method based on interval intuitionistic integrated cloud Petri nets, which is applied to a subway fire accident model.

We conclude this editorial by thanking all the authors for their high-quality contributions. We are also indebted to all associate editors and anonymous reviewers for their professional and valuable work that helped improve all manuscripts. Likewise, we express our gratitude to the TRANSACTIONS' Editor-in-Chief (EiC), Prof. Yu Sun, to the former EiC, Prof.

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APPENDIX: RELATED ARTICLES

[A1] Y. Xiang, J. Yang, X. Li, and C. Gu, "Routing optimization of electric vehicles for charging with event-driven pricing strategy," *IEEE Trans. Automat. Sci. Eng.*, early access, Aug. 19, 2021, doi: 10.1109/TASE.2021.3102997.

[A2] M. P. Fanti, A. M. Mangini, M. Roccotelli, and B. Silvestri, "Innovative approaches for electric vehicles relocation in sharing systems," *IEEE Trans. Automat. Sci. Eng.*, early access, Aug. 20, 2021, doi: 10.1109/TASE.2021.3103808.

[A3] E. De Angelis, C. Carnevale, G. Di Marcoberardino, E. Turrini, and M. Volta, "Low emission road transport scenarios: An integrated assessment of energy demand, air quality, GHG emissions and costs," *IEEE Trans. Automat. Sci. Eng.*, early access, Apr. 29, 2021, doi: 10.1109/TASE.2021.3073241.

[A4] G. Ferro, R. Minciardi, L. Parodi, and M. Robba, "Optimal planning of charging stations in coupled transportation and power networks based on user equilibrium conditions," *IEEE Trans. Automat. Sci. Eng.*, early access, Mar. 26, 2021, doi: 10.1109/TASE.2021.3066001.

[A5] T. Rahman, Y. Xu, and Z. Qu, "Continuous-domain real-time distributed ADMM algorithm for aggregator scheduling and voltage stability in distribution network," *IEEE Trans. Automat. Sci. Eng.*, early access, Apr. 28, 2021, doi: 10.1109/TASE.2021.3072932.

[A6] K. Ojand and H. Dagdougui, "Q-learning based model predictive control for energy management in residential aggregator," *IEEE Trans. Automat. Sci. Eng.*, early access, Jul. 9, 2021, doi: 10.1109/TASE.2021.3091334.

[A7] A. M. Helmi, R. Carli, M. Dotoli, and H. S. Ramadan, "Efficient and sustainable reconfiguration of distribution networks via metaheuristic optimization," *IEEE Trans. Automat. Sci. Eng.*, early access, May 4, 2021, doi: 10.1109/TASE.2021.3072862.

[A8] G. Cavone, T. van den Boom, L. Blenkers, M. Dotoli, C. Seatzu, and B. De Schutter, "A rescheduling algorithm for disruptions and disturbances in large-scale railway networks," *IEEE Trans. Automat. Sci. Eng.*, early access, Dec. 17, 2020, doi: 10.1109/TASE.2020.3040940.

[A9] Y. Chen, D. Huang, Y. Li, and X. Feng, "A novel iterative learning approach for tracking control of high-speed trains subject to unknown time-varying delay," *IEEE Trans. Automat. Sci. Eng.*, early access, Dec. 22, 2020, doi: 10.1109/TASE.2020.3041952.

[A10] M. Kalikatzarakis, A. Coraddu, L. Oneto, and D. Anguita, "Optimising fuel consumption in thrust allocation for marine dynamic positioning systems by kalikatzarakis," *IEEE Trans. Automat. Sci. Eng.*, early access, Apr. 8, 2021, doi: 10.1109/TASE.2021.3069779.

[A11] D. An, Q. Yang, D. Li, W. Yu, W. Zhao, and C.-B. Yan, "Where am I parking: Incentive online parking-space sharing mechanism with privacy protection," *IEEE Trans. Automat. Sci. Eng.*, early access, Oct. 7, 2020, doi: 10.1109/TASE.2020.3024835.

[A12] C. Zhang, G. Tian, A. M. Fathollahi-Fard, W. Wang, P. Wu, and Z. Li, "Interval-valued intuitionistic uncertain linguistic cloud petri net and its application to risk assessment for subway fire accident," *IEEE Trans. Automat. Sci. Eng.*, early access, Oct. 7, 2020, doi: 10.1109/TASE.2020.3014907.

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