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Extended Abstract Submission

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Dynamic charging solutions for future mobility: A viability review

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This work addresses the following topic(s) from the Call for Contributions:
(Please check at least one box)

☐ Placemaking to integrate urban spaces and mobility
☒ Promoting sustainable mobility choices in metropolitan regions
☐ Governing responsible mobility innovations
☐ Shaping the transition towards mobility justice
☒ System analysis, design, and evaluation
☐ other: ________________________

Extended Abstract

Problem statement

The rapid rise of electric vehicles (EVs) signifies a pivotal shift towards cleaner and more sustainable transportation, aligning with global efforts to combat climate change and reduce greenhouse gas emissions. EVs are instrumental in achieving greener, low-carbon transportation. In addition to their environmental advantages, EVs outperform alternative technologies, such as internal combustion and fuel cell vehicles, in terms of energy efficiency, CO2 emissions reduction, and fuel costs.

Simultaneously, the emergence of Autonomous Vehicles (AVs) has gained significant traction in the transportation landscape. AVs promise safer roads, decreased accident rates, and improved accessibility, particularly for individuals with limited mobility options. These vehicles have far-reaching societal implications, impacting urban planning, traffic management, and overall transportation efficiency.

Expanding beyond AVs, the future mobility landscape encompasses shared mobility, modular vehicles, and urban air mobility. Shared mobility models, featuring ride-sharing services and communal vehicle use, offer an efficient approach to resource utilization, reducing urban congestion and environmental footprints. Modular vehicles, characterized by variable-length platoons, cater to diverse passenger needs, enabling the same vehicle to serve multiple purposes. Urban air mobility (UAM) proposes air transportation solutions for both cargo and passengers in urban environments, aiming to alleviate congestion and reduce travel times.

Amid this evolving mobility paradigm, a versatile and adaptable charging infrastructure is essential. Beyond conventional charging stations, innovative concepts like dynamic charging, which supplies power to vehicles while in motion thereby reducing battery capacity and weight, present novel solutions for meeting the energy requirements of both EVs and AVs.

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Research objectives

To leverage the advantages of autonomous vehicles and dynamic charging, various innovative charging techniques are being explored including refurbished buses, battery swapping drones and laser and radio-wave charging. These methods harness autonomous vehicle capabilities to offer charging services without relying on costly charging infrastructure. It has become imperative to review, analyse and categorize these charging methods to assess their performance and challenges. However, from our survey of recent literature reviews on EV charging methods, we found a lack of studies considering new state-of-the-art dynamic charging methods. Moreover, these dynamic charging methods are not considered in detail regarding potential pros and cons, integration with AVs and comparison with other dynamic charging methods.
From the survey of review works, the following research gaps are identified. We aim to evaluate and categorize the charging methods to address these research gaps:

1. None of the existing review studies classify or investigate different dynamic charging methods and their associated challenges and opportunities, particularly concerning future mobility.
2. Recent advancements in charging methods and technologies are underrepresented in the literature.
3. The impact of autonomous vehicles and evolving transportation trends on different charging methods and their potential benefits have been mentioned as future directions but remain largely unexplored.
4. Comparison among these charging methods is insufficient, hindering the selection of the most suitable approach for specific scenarios and conditions. These charging methods are not compared with each other, thereby hindering the identification of which charging method will best suite specific scenarios and conditions.

Methodological approach

To address these research gaps, we classify charging methods as either static/stationary (vehicle parked) or dynamic (vehicle in motion). Static charging includes fixed chargers with designated charging locations, mobile chargers with flexible locations, and battery swapping at designated facilities. As we consider static charging to be incompatible with future transport, they are only considered briefly.
Dynamic charging encompasses charging lanes (conductive or inductive), vehicle-to-vehicle transfers (conductive or inductive), and dynamic battery swapping as shown in Figure 1. These dynamic chargers can also provide stationary charging capabilities with minimal adjustments.

To analyse similar research and recent advancements in charging infrastructures, a set of keywords were used to search the databases of google scholar, web of science and Scopus to find relevant scientific literature. As the amount of literature available is extensive we employ a coarse-grained inclusion, where the search is stopped when 10 titles unrelated to subject area appeared.

We also utilized AI tools like semantic scholar, sci-space and research rabbit to find relevant reports and literature by using the relevant literature as seed papers. When new relevant literature are identified, they are added as seed papers to train the AI tools to find similar research. The search was conducted in October 2023 and only peer-reviewed, English language papers published after 2016 were taken into consideration as EV charging is a fast-evolving domain. Based on the relevance of the studies from various databases, 107 papers were reviewed.

(Expected) results

As the domain of EV charging is rapidly advancing, we aim to bridge the knowledge gap of synergies between state-of-the-art dynamic charging and new trends in transportation like autonomous vehicles, shared and modular mobility. This review will be beneficial to researchers and planners to find which charging solution best suits their needs and compare them with alternative solutions. With that aim, the main contributions of this study can be listed as follows:

- A new classification of EV charging methods considering the motion of EVs (whether idle or moving) is provided. Synthesizing state-of-the-art dynamic charging solutions, their applications, and the implications of this technology on the automotive industry and sustainable transportation.
- The various dynamic charging methods are critically assessed and their pros and cons compared across various factors to see their viability in meeting the energy needs for future transport.
- The knowledge gaps, barriers and opportunities of dynamic charging are identified as well as future research directions.

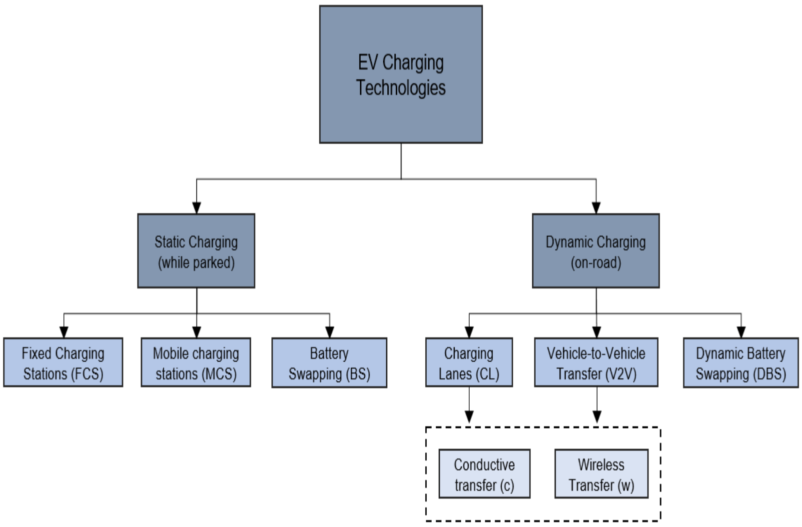

Figure 1: Classification of EV chargers