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# Electric mobility toward sustainable cities and road-freight logistics: A systematic review and future research directions

Frank E. Alarcón [a] 🖂 , Alejandro Mac Cawley [a], Enzo Sauma [a b]

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## Abstract

The importance of electric vehicles (EVs) lies in the fact that they are seen as a key solution to the climate change problem. In the last decade, this topic has received significant interest from the scientific community, contributing to publications in different areas. However, the existing literature is fragmented, and efforts have not been made to categorize and analyze it from a freight logistics perspective. This work aims to fill this gap by presenting a systematic literature review (SLR) of the potential impacts of EVs on sustainable road-freight transport operations, including in urban areas. We reviewed 237 peer-reviewed articles for bibliometric and literature classification analysis, whereby 119 articles were subsequently studied for content analysis and research gaps related to sustainability approaches. The bibliometric analysis showed significant growth in the body of research in the past two years, reflected in the number of journal papers, authors, and references. In the literature and keywords analysis, we identified five main categories and research areas: economic and competitive aspects, city logistics, environmental sustainability, vehicle fleet operations, and infrastructure and technology. In addition, this paper revealed eight key research gaps for future research: multimodal integration, long-haul and heavy-duty truck approaches, emerging economies, business models, social factors, charging infrastructure inclusion, and fleet replacement policies. These findings can enlighten researchers and practitioners toward sustainable research and real-life applications of electromobility in freight logistics.

## Introduction

Transportation is an essential component in the development of societies due to its economic and environmental impacts. Typically, between 6 and 8% of company costs can be attributed to transport (Ivanov et al., 2019), and this

sector is responsible for about 24% of direct $CO_2$ emissions from fuel combustion globally (Rasti-Barzoki and Moon, 2021; Zhao et al., 2022). Road transportation (including commercial and passenger) accounts for approximately 75% of transport $CO_2$ emissions (Zhao et al., 2022). Even though freight transport operations account for only 10–15% of vehicle movement in cities, overall transport operations account for up to one-third of traffic-related emissions (Dablanc, 2007; Kin et al., 2021). Hence, from an environmental perspective, electric vehicles (EVs) are the most promising instrument for lowering greenhouse gas (GHG) emissions. However, even though sales have tripled since 2018 (IEA, 2022), EV penetration into the market is still low (especially in emerging markets) and mainly dominated by passenger vehicles and buses. Globally, the electric light commercial vehicle (eLCV) sector has a market share of 2%, about four times less than passenger cars (IEA, 2022). The worldwide market shares of electrically-chargeable delivery vehicles and hybrid delivery vehicles in 2019 were only 1.2% and 0.2%, respectively (Osieczko et al., 2021). Considering trucks in the medium and heavy categories, electric trucks still have an incipient market share of 0.1% of the global fleet (IEA, 2022).

High upfront costs are one of the major barriers that must be overcome for EVs to be widely adopted in fleets (Qasim and Csiszár, 2021). The instability of electricity prices and the availability of charging infrastructure (Figura and Gądek-Hawlena, 2022), unevenly scattered recharging facilities (Ghamami et al., 2020; Raeesi and Zografos, 2020), and range anxiety all make EVs less attractive in the logistics domain. However, in an effort to meet environmental commitments, many governments are looking for enablers in the adoption of EVs in cities, through public subsidies and enforcing other non-financial incentives to promote their uptake.

Even though city logistics (CL) has been studied in the last decades, the subject is constantly changing, especially with the arrival of novel technologies and business models. In addition, reviews on CL issues have been developed from a holistic perspective (Hu et al., 2019; Lagorio et al., 2016; Neghabadi et al., 2019) without focusing solely on EVs. Other reviews on freight logistics generally do not consider major electromobility settings, although some can include sustainable approaches. Some of these approaches include business logistics (Goldsby et al., 2019), reverse logistics of end-of-life vehicles (He et al., 2020), truck logistics and emissions (Inkinen and Hämäläinen, 2020), e-commerce logistics (Cano et al., 2022), last mile and urban freight distribution (de Oliveira et al., 2017; He, 2020; Mucowska, 2021; Olsson et al., 2019), sustainable vehicle routing (Dündar et al., 2021; Ghorbani et al., 2020) and sustainable transport (Zhao et al., 2020). On the other hand, reviews related to electromobility are quite fragmented and reveal a staggering variety of approaches. The reviews can include topics such as optimization models for EV operations (Shen et al., 2019), sustainability assessment of EVs (Onat and Kucukvar, 2022), urban mobility with autonomous EVs (Kovacic et al., 2022), EV adaptation and infrastructure (Manikandan and Gudipalli, 2022), second-life Li-ion batteries and circular economy (Shahjalal et al., 2022; Sopha et al., 2022), green supply chain management's futuristic technologies (Wangsa et al., 2022), and integration of sustainable transportation and smart grids (Casella et al., 2022).

Although there are reviews that focus separately on either EVs or logistics operations, fewer reviews address these topics together. Some of these works include market and technological perspectives (Pelletier et al., 2016), promotion policies (Qiao and Raufer, 2022), and the intensively studied topic of vehicle routing problems (VRP) with EV settings (Dammak et al., 2019; Erdelic and Carić, 2019; Kucukoglu et al., 2021; Qin et al., 2021; Xiao et al., 2021b; Ye et al., 2022).

Most of the review articles above focus on city logistics but not solely on EVs. Likewise, the studies in freight logistics consider environmental factors but neglect the major roles of EVs. These facts highlight the need for a comprehensive literature analysis covering the linkage between EVs and road-freight logistics, including in urban areas. Hence, this SLR fills this research gap and contributes first by performing a bibliometric analysis using science mapping techniques and determining the evolution of the research, the groups of researchers, and journals focused on this topic, identifying that literature has grown significantly in the last two years. Second, using

keywords, we classified the literature into five main research categories or topics related to electromobility and freight logistics, namely economic and competitive aspects, city logistics, environmental sustainability, vehicle fleet operations, and infrastructure and technology. Finally, this review contributes to the knowledge by defining research sub-topics for the aforementioned categories by identifying eight gaps and future research directions regarding sustainable development. These future research lines can include multimodality, social factors, emerging economies, fleet replacement policies, business models, and long-haul trucking.

EVs in fleets likely influence the entire supply chain, creating challenges and difficulties for businesses, auto manufacturers, governments, and stakeholders, as they need to rethink their strategies and goals. Thus, in practice, businesses and authorities must be aware of the state of the art and have tools to analyze the feasibility and competitiveness of EVs as a replacement for traditional vehicles to achieve the goal of greener logistics. The scientific community should assess and inform research developed by researchers to expand knowledge about the environmental and economic impacts of the penetration of EVs in fleets, as well as analyzing case studies and available technologies and techniques. This paper contributes by addressing the issues above by identifying major research gaps, what has been studied, and what still needs to be researched.

To determine the main topics and opportunities related to electromobility and freight logistics and the potential future research directions regarding sustainable development, we performed a systematic literature review (SLR) based on some review articles detailed in the methodology, such as the one proposed by Peterson et al. (2017). To achieve the study's objectives, we proposed the following three research questions (RQ).

**RQ1**

Has the body of research on electromobility and freight logistics recently grown? Are there groups of researchers and journals focused on this topic?

**RQ2**

Could the scientific literature's main research categories, topics, and trends related to electromobility and freight logistics be grouped and characterized?

**RQ3**

What are (if any) the research gaps, challenges, and potential future research possibilities in these categories or topics related to sustainability?

In this respect, this research has the following motivations and objectives: a) to provide bibliometric information on 237 scientific studies extracted from Scopus and Web of Science databases using a structured query; b) perform bibliometric analysis using science mapping analysis software; c) analyze the evolution over time of the research published on electromobility and freight logistics, the most relevant journals that serve as an outlet for them, in addition to conducting author, citation, and co-authorship analyses to understand the network of this research field; d) classify the literature into main categories or research areas; e) search, analyze, and synthesize categories and studies based on sustainable indicators; and f) identify knowledge gaps and research prospects to contribute theoretically and practically to the impact of EVs on sustainable road transport logistics operations.

The rest of the paper is organized as follows. Section 2 presents a theoretical framework for sustainable cities, freight logistics, and electric mobility. Section 3 explains the methodology used in the SLR, describing the articles' searching procedure, classification, and analysis, which will lead to answering the research questions. Section 4 presents some bibliometric results from the selected articles, allowing us to answer RQ1. In Section 5, we answer RQ2 and classify the main topics and trends in the literature. Section 6 presents the literature review results and the main findings analyzed and synthesized, allowing us to answer RQ2. Section 7 discusses the significant results, the

main research gaps, and the challenges leading to possible future research lines to answer RQ3. Finally, Section 8 concludes the paper, acknowledges its possible limitations, and summarizes future research directions (RQ3).

## Section snippets

## Theoretical framework in sustainable city and freight logistics and electric mobility

Regarding modern trends such as urbanization or the rise in citizens' expected levels of welfare, city logistics is one of the most critical concerns in the majority of cities across the world (Bozzo et al., 2014; Neghabadi et al., 2019). Terms such as city logistics (CL), urban logistics, or urban freight logistics are often used interchangeably and aim to reduce negative transport externalities such as traffic, safety, and environmental pollution. Several approaches have been proposed to …

## Research methodology

We highlight the SLR performed in this study as a method that allows for finding previous studies, examining contributions, synthesizing data, finding gaps, drawing conclusions based on existing works, analyzing trends, and proposing original fields of future research (He, 2020; Neghabadi et al., 2019; Thomé et al., 2016). It is not a simple review of previous writings (Thomé et al., 2016). It is systematic because it is based on research questions and uses a systematic approach or methodology …

## Bibliometric analysis

We performed a bibliometric analysis on the 237 selected papers, presenting the descriptive statistics of dates, authors, references, and co-authorship analysis to answer RQ1. …

## Literature classification

We extracted keywords representing each article's scope to determine a classification regarding the literature and performed a keyword analysis to obtain a valid classification of the main subject areas. The keywords found were numerous and very diverse, revealing the magnitude and scope of the topic. We adapted the categorization method according to the method used in the work by Neghabadi et al. (2019). Fig. 5 presents the categorization cluster analysis using the keywords.

A total of 759 …

## Results: analysis of categories

We performed content analysis within each targeted cluster. Due to the vast magnitude of the topic, it is necessary to find the categories that best focus on the article's topic. The categories belonging to economic and environmental factors are framed within the term "sustainability". Likewise, the CL category falls within the article's topic on urban areas. Therefore, these three categories are chosen to analyze and synthesize their content. However, the other two groups are also partly …

## Discussion

The quantitative analysis carried out in this article allowed us to identify bibliographic characteristics of the impacts of electromobility on road-freight logistics and cities (RQ1). In the bibliometric analysis, we studied 237 articles authored by 755 authors and published in 94 journals. No papers related to this research field were observed before 2011. From that year on, there has been a growing trend in the number of papers published in this research field, but in the last two years, the …

## Conclusions and future research perspectives

Electromobility and freight logistics – two multidisciplinary topics – have received attention in the research community from different directions. Even though EVs have been a hot topic for a decade now, their use for distribution activities is still incipient, even more so when dealing with large shipments. This review fills that gap by treating it in an integrated manner and providing researchers and practitioners with a tool to understand and assess the impacts of EVs on freight logistics …

## CRediT authorship contribution statement

**Frank E. Alarcón:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Visualization, Project administration, Funding acquisition. **Alejandro Mac Cawley:** Methodology, Writing – review & editing, Validation, Supervision. **Enzo Sauma:** Methodology, Resources, Writing – review & editing, Supervision, Validation. …

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

## Acknowledgements

Special issue articles        Recommended articles

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Optimization and implementation strategy for low-carbon multimodal transport routes: A collaborative approach between government and transport enterprises

2025, Journal of Cleaner Production

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Low-carbon route optimization model for multimodal freight transport considering value and time attributes

2024, Socio Economic Planning Sciences

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## Carbon reduction effects of electric delivery vehicle adoption in Chinese cities: Gradient pattern and scenario analysis

2024, Energy

> *Citation Excerpt :*
>
> …The Gompertz model, linear regression, and machine learning models have been employed to predict the number of EVs or trucks in future scenarios. Most of the current research about the low-carbon transition of urban freight transport focuses on developed countries, while developing countries are ecologically and economically more vulnerable and deserve more attention [56]. Meanwhile, only a few studies have paid attention to accurately assessing the drivers of urban delivery demand and carbon emissions at the city scale, which is crucial for low-carbon transition of urban transport system.…

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2024, Journal of Cleaner Production

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