

Electric Vehicle: A Bibliometric Analysis of Future Trends

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Abstract

Carbon-based emissions from greenhouse gases (GHGs) from transportation make a harmful impact on climate change and human health. The traditional combustion of vehicles makes severe consequences on the environment. Electric vehicles are regarded as a key technology to decarbonize the road transport sector for environmental protection and sustainability because the EVs reduce the carbon footprint, dependence on fossil fuels, and noise levels and increase the efficiency of conversion. The research about EVs has significantly increased since 2018 because EVs are used in practical transportation. This paper provides essential information on emerging trends and the Future of research involving EVs. The method used in this paper is to use five stages of screening and the application of VOS viewer for constructing and visualizing bibliometric networks. Based on the results obtained, the most frequently used keywords in research related to electric vehicles are electric vehicles, electric vehicle batteries, and electronic waste. Research on electric vehicle batteries will still be interesting research to discuss in the next few years. In addition, the topic of energy and environment is also a topic that must be raised because the final product from used batteries is still an obstacle for every country that has started to switch from ICE to EV.

Keywords

Electric Vehicle, Bibliometrics, VOS viewer, Future Research, and Greenhouse Gases.

1. Introduction

Carbon-based emissions from greenhouse gases (GHGs) from transportation make a harmful impact on climate change and human health. The traditional combustion of vehicles makes severe consequences on the environment (Thorhaug et al., 2020). Electric vehicles are regarded as a key technology to decarbonize the road transport sector for environmental protection and sustainability (Hou et al., 2022). The EVs reduce the carbon footprint, dependence on fossil fuels, and noise levels and increase the efficiency of conversion (Xie et al., 2020). The EVs require fewer number components as compared to the internal combustion engine (ICE) (Islam et al., 2022). EVs can replace conventional internal combustion engine vehicles (ICEV) (Kumar & Revankar, 2017). Promoting electric vehicles (EVs) to phase out conventional internal combustion engine (ICE) vehicles soon is a crucial strategy for worldwide countries (Chen et al., 2020). Increasing EVs in circulation can reduce transport costs and the effects of greenhouse gas emissions, compared to fossil-fuel-powered engines in addition to strengthening electric mobility through the high penetration of renewable energy sources (Kucukoglu et al., 2021).

The research about EVs has significantly increased since 2018 because EVs are used in practical transportation, e.g., personal vehicles and taxis. In common car markets, commercial EVs include hybrid electric vehicles (HEVs), plug-in hybrid vehicles (PHEVs), and battery electric vehicles (BEVs) (Suttakul et al., 2022). The rising demand for electric vehicles is due to their several advantages over conventional vehicles. Studies have shown that electric vehicles are energy efficient in that about 60% of the electrical energy from the grid is converted to power at the wheels compared to about 20% of the energy stored in gasoline for powering at the wheel for internal combustion engine vehicles (Liu et al., 2018). In addition, an electric vehicle has zero emission of carbon dioxide and other tailpipe pollutants as well

as less maintenance, smooth operation, and stronger acceleration compared to internal combustion engine vehicles (Ayodele & Mustapa, 2020).

To investigate the current state of the art on electric vehicles and to provide guidance on emerging trends in studies related to EVs, a search was carried out in the SCOPUS database and is presented in this work. This paper provides essential information on emerging trends and the Future of research involving EVs. It also identifies hotspots that might be interesting as research areas.

1.1 Objectives

This paper aims to investigate the current state of the art in electric vehicles and provides essential information on emerging trends and the future of research involving EVs.

2. Literature Review

2.1 Electric Vehicle

Electric vehicles that are powered by electricity are usually driven by electric motors coupled with rechargeable batteries (Feng et al., 2018). There exist different types of electric vehicles depending on the power source (Adnan et al., 2018). In terms of technologies and strategies, it is agreed that EVs can be grouped into five categories as highlighted in Figure 1.

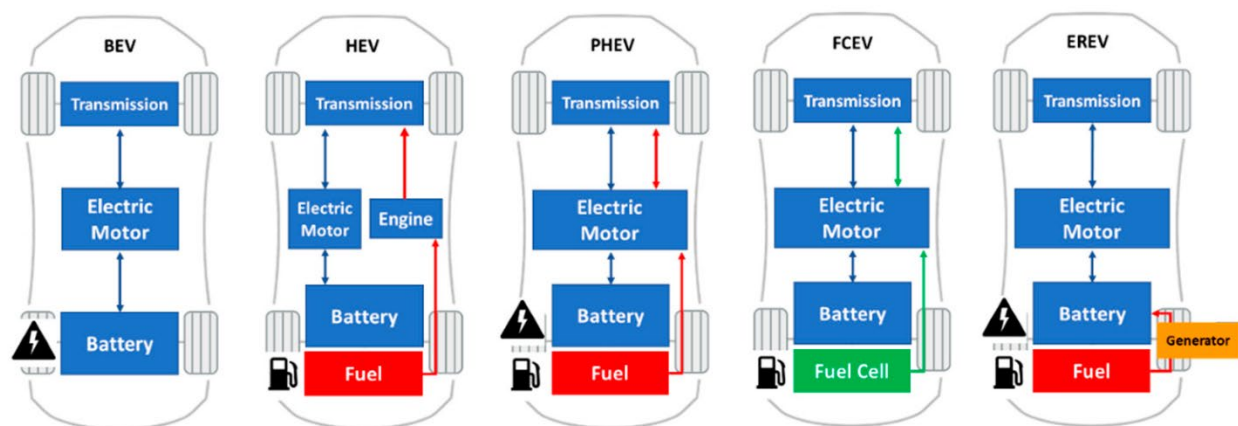


Figure 1. EV Type and Categories

- Battery Electric Vehicles (BEVs) are powered 100% by electricity. BEVs consist of an energy storage battery, an electric motor, and a controller. The electric battery can be recharged using energy from the mains by a charger, which can be exclusive to the vehicle or installed in a charging station (Sam & Jegathesan, 2021).
- Hybrid Electric Vehicles (HEVs) have two power units, a conventional internal combustion engine and an electric motor (Hemanth et al., 2021). The HEVs are not loaded into the electrical grid but through the energy generated in braking, transforming kinetic energy into electrical energy (Sanguesa et al., 2021).
- Plug-In Hybrid Electric Vehicles (PHEVs) are composed of an internal combustion engine and an electric motor. PHEVs are gasoline moved and have a large battery that can be charged via an external plug in the electrical network. The difference with HEVs is that they can be connected to the mains (Goel et al., 2021).
- Fuel Cell Electric Vehicles (FCEVs) use electric power trains such as BEVs; however, they generate electricity using a fuel cell powered by hydrogen. FCEVs are classified as zero-emission vehicles (Arif et al., 2021).
- Extended Range Electric Vehicles (EREVs) are equipped with a supplementary internal combustion engine, which charges the vehicle's batteries, if necessary. Unlike PHEVs and HEVs, the engine of EREVs is used for charging only, without connection to the wheels (Puma-Benavides et al., 2021).

3. Methods

The method used is by using the keywords “electric vehicle” and “waste” in the SCOPUS database. There are 5 screenings carried out. Primary screening is based on the keywords “electric vehicle” AND “waste”. Secondary screening is based on the language used, namely English. The third screening is based on data from the last 10 years’ manuscripts. The fourth screening was based on the last 3 years of manuscripts and the final screening was based on the document type used, namely article and conference paper, and the scope of the manuscripts was narrowed down based on the subject area, namely social science, business, management and accounting, economics, econometrics, and finance. The software used in writing this paper is VOS Viewer 1.6.18 which functions for constructing and visualizing bibliometric networks. From the output of the software, the highest occurrence value will be sought to determine the development of research on electric vehicles. (Figure 2)

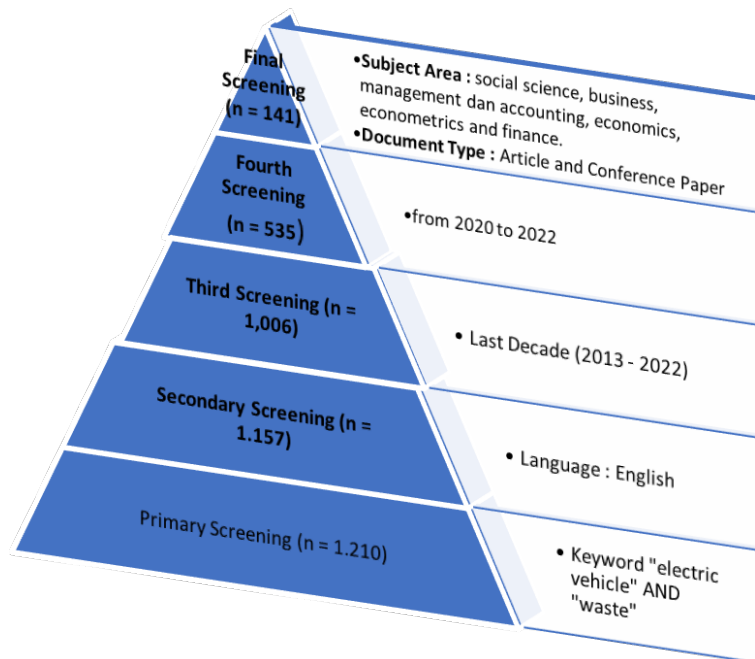


Figure 2. Methods

4. Data Collection

The data used is data based on a database from SCOPUS. Search data based on the keywords "electric vehicle" and "waste". The data was obtained using 5 times of screenings. Primary screening obtained 1,210 manuscripts that match the keywords. Then a secondary screening was carried out based on the language used, namely English, and obtained 1,157 manuscripts. Furthermore, a third screening was carried out based on the database of the last 10 years, which obtained 1,006 manuscripts. A fourth screening was carried out based on the database on Scopus for the last 3 years, obtaining 535 manuscripts. Finally, a final screening was carried out by using document types in the form of articles and conference papers, then the subject area was reduced based on social science, business management and accounting, economics, econometrics, and finance. A total of 141 manuscripts were obtained.

5. Results and Discussion

5.1 the development of research on electric vehicles based on the Scopus database

The development of research on electric vehicles based on the Scopus database and the keywords “electric vehicle” AND “waste” is divided into several stages based on the year of research in the SCOPUS database, namely research developments from 1980-2022, research for the last 10 years from 2013-2022, research the last 3 years from 2020-2022, and the last 10 years from 2013-2022, but made more specific based on the document type and subject area of the research.

5.1.1 Research Developments from 1980 to 2022

Research developments related to electric vehicles with the keywords "electric vehicle" AND "waste" in the SCOPUS database obtained 1,210 manuscripts. Based on these manuscripts, the VOS Viewer 1.6.18 application was used for visualizing bibliometric networks so that the most widely used keywords in research on electric vehicles could be identified. Based on the application, the top 10 keywords that often appear are taken based on the occurrence value obtained from the VOS viewer application. The 10 keywords can be seen in Table 1.

Table 1. The Top 10 Keywords From 1980 to 2022* (June)

No	Keyword	Occurrence
1	electronic waste	300
2	electric vehicle battery	291
3	electric vehicle	278
4	recycle	232
5	energy	169
6	environment	124
7	secondary batteries	86
8	waste heat	79
9	life cycle	73
10	sustainability	67

Based on Table 1, electronic waste is the keyword that most often appears, namely 300 events, followed by electric vehicle battery 291 events, electric vehicle 278 events, and recycle 232 events. from 1980 to 2022, electronic waste is still the research topic that is the highest choice.

5.1.2 Research Developments From 2013 to 2022

This secondary screening aims to determine the development of research on electric vehicles in the last 10 years from 2013-2022 in the SCOPUS database, which is based on occurrences obtained from the VOSViewer application. The top 10 most frequently appearing keywords can be seen in Table 2.

Table 2. The Top 10 Keywords From 2013 to 2022* (June)

No	Keyword	Occurrence
1	electric vehicle	525
2	electronic waste	429
3	electric vehicle batteries	423
4	recycle	366
5	environment	213
6	secondary batteries	180
7	waste heat	177
8	solid waste	164
9	life cycle	132
10	sustainability	123

Based on Table 2, the ranking of the top 10 types of research on electric vehicles from 2013-2022 based on keywords that often appear does not change too much. Only one keyword suddenly rose to the top of the rankings, namely solid waste. While the top three are still filled by electric vehicles, electronic waste, and electric vehicle batteries.

5.1.3 Research Developments From 2020 to 2022

Screening on research developments from 2020-2022 based on the SCOPUS database obtained 535 manuscripts. Based on the VOSViewer application, the top 10 most frequently used keywords can be seen in Table 3.

5.2 Proposed Improvements

Research on electric vehicles is a topic that is currently attracting the attention of researchers. Various aspects can be researched, such as regarding recycling, environment, sustainability, battery, and others. The development of research on electric vehicles that will still be widely discussed is related to batteries, both regarding the material of the battery, durability, recycling, charging process, and others. The next is related to the energy and environment of electric vehicles which will attract attention and continue to grow.

6. Conclusion

The electric vehicle is a very interesting topic to be researched lately. Research on EVs has greatly increased since 2018 because EVs are widely used in public transportation. Based on bibliometrics that has been carried out on the SCOPUS database based on the occurrence value of keywords that are often used in research, electric vehicles, electric vehicle batteries, and electronic waste are the top three most frequently used keywords. As for the development of research in the next few years, the topic of batteries in electric vehicles is still an interesting topic to research. In addition, the topic of energy and environment is also a topic that must be raised because the final product from used batteries is still an obstacle for every country that has started to switch from ICE to EV.

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Biography

Arief Nurdini is a junior lecturer at Gunadarma University. He earned Bachelor in Industrial Engineering Department, Gunadarma University Depok, Indonesia and he obtained his Master's Degree in Mechanical Engineering Department, Gunadarma University, Depok, Indonesia. Now he is carrying out his Doctoral study assignments in the Industrial Engineering Department, Universitas Indonesia.

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