

# Global Research Trends and Indonesia's Position in The Development and Application of Electric Trucks: A Literature Review

**Benazir Imam Arif Muttaqin, Domingo Bayu Baskara, Muhammad Miftahul Abidin,  
and Hendrawan Widiyanto**

Industrial Engineering Department

Faculty of Industrial and Information Technology

Institut Teknologi Telkom Surabaya, Indonesia

[benazir.imam.a.m@ittelkom-sby.ac.id](mailto:benazir.imam.a.m@ittelkom-sby.ac.id), [domi@ittelkom-sby.ac.id](mailto:domi@ittelkom-sby.ac.id),

[mmiftabidin@student.ittelkom-sby.ac.id](mailto:mmiftabidin@student.ittelkom-sby.ac.id), [hendrawan.widiyanto.19@student.ie.ittelkom-sby.ac.id](mailto:hendrawan.widiyanto.19@student.ie.ittelkom-sby.ac.id)

## Abstract

To deal with environmental issues, government, medium and large industries should start considering electrifying conventional vehicles. Currently, it is suspected that research that discusses the conversion of fossil fuel-based trucks to electric trucks is still low, not only in Indonesia but also globally. This research discusses a literature study on the development and application of electric vehicles (EVs), electric trucks, and the conventional vehicle conversion. The literature study was carried out using the Scopus database. The keywords used in the search include electric vehicle, electric car, electric bus, electric truck, and electric truck conversion. The literature review has been conducted as comprehensive as possible, including the distribution of publication quantity based on countries, subject areas, and the scope of research objects. Based on the results of a literature study, it is concluded that research on EV in Indonesia is still low compared to other countries in terms of the quantity of publications. Indonesia is quite able to compete in terms of research on passenger EVs (cars and buses) but research on EVs development for trucks and its conversion are still low. This findings can be used as a reference in developing EVs researches in the future.

## Keywords

electric vehicle (EVs), truck conversion, electric truck, literature review

## 1. Introduction

The issues of climate change, carbon emissions, and greenhouse gases have an impact on the quality of life and humans health, as well as Earth's ecosystems (McMichael *et al.*, 2003). These problems force the government, researchers, manufacturers, and environmentalists to develop alternative renewable energy solutions. One solution that can be done is to develop electric vehicles (EVs) to substitute the use of conventional fossil-based fuel vehicles. To apply electric vehicles widely, support from researchers who are experts in their fields related to basic research, development, and later applied research is needed before the product can actually be widely used in society.

Electric vehicles now have many varieties ranging from electric cars, electric motorcycles, electric buses, to electric trucks. In the early days of the development of electric vehicles, types of passenger vehicles such as electric cars and electric buses received a lot of attention from various researchers and large companies. However, it is undeniable that the daily needs of society and industry in supporting the current economy do not only rely on transportation from passenger vehicles, but also logistic transport vehicles (Leemput *et al.*, 2012). Moreover, in countries with large logistical problems such as Indonesia. Therefore, the direction and research opportunities on the development and application of electric trucks as a mode of transportation that is widely relied on to send logistics is a real opportunity that should be captured by researchers, the government, as well as investors of large companies.

To examine these problems, this study conducted a literature review on research trends in Indonesia and globally in the development and application of electric trucks. The purpose of this research is to get an idea of how the trend of development and application of electric trucks globally is and how Indonesia's position and research opportunities will be in the future. So far there have been several studies that discuss the trend of electric vehicle research in general. In (Frieske, Kloetzke and Mauser, 2013), it is explained that hybrid and battery electric vehicles have been widely

introduced to the market, especially during 2002-2012. Various other literatures also support and state that the trend of research and development of EVs and its system including the development of batteries, charging systems, mechanical systems, control systems, motor systems, and other support systems has increased rapidly, as shown in (Zheng *et al.*, 2011; Kaneko and Abe, 2013; Rajashekara, 2013; Braun, Armbruster and Gauterin, 2015; Wang *et al.*, 2018; Ambrose *et al.*, 2020; Krings and Monissen, 2020).

## 2. Methodology

The limitation used in this literature study is that the search is carried out on articles that have been published from 1945 to March 2021. The search was carried out on Scopus, the largest database of abstracts and citations on the internet. This limitation ensure the article data obtained related to certain keywords. The search involved all subject areas, all forms of documents (proceedings articles, journals, book chapters). Article searches are also carried out without limiting the country.

The keywords used in the article search include: “electric vehicle”; electric AND car; “electric cars”; electric AND buses; “electric buses”; electric AND trucks; “electric trucks”; electric AND vehicle AND conversion; “electric vehicle conversion”; “electric truck conversion”; and electric AND truck AND conversion. The use of double quotation marks (“ ”) is intended to obtain article data derived from phrases of the desired term/terminology. For example, if the keyword: “electric truck” is used, then the article search results will display all articles that use the keyword “electric truck”. While the use of ‘AND’ is intended to obtain data for articles that use each keyword. For example, if the keyword: electric AND truck is used, the article search results will display all articles that use the keywords “electric” and “truck”. The search results are then collected and analyzed comprehensively.

## 3. Results and Discussion

### 3.1 Research Related to Electric Vehicles (EVs)

Based on the search using the keyword: “electric vehicle”, 31,226 documents were found from 1955 to 2021. From the distribution of published years, year to year research quantity on electric vehicles has increased significantly, especially from 2009 to 2019. In 2010, the number of documents researching on “electric vehicles” has reached more than 1000 new titles, and almost touched 3,900 new article titles by the end of 2019. Based on the country of origin, China and the United States contributed the most to research publications associated with “electric vehicles”. Indonesia is ranked 31st as a contributor to research on “electric vehicles”. Based on the three largest subject areas, 40.9% of the total research titles are in the engineering field, 17% in the energy, 12.3% in the field of computer science.

From the search results that have been carried out, articles about electric vehicles with the most citations in the last 5 years (2017-2021) are presented in Table 1.

Table 1. Research on Electric Vehicles with the Most Citations (2017-2021)

Title	Source	Country	Year	Subject Area	Object of the Research	Ref.
Batteries and fuel cells for emerging electric vehicle markets	Nature Energy	Canada	2017	Energy	Batteries and fuel cells	(Cano <i>et al.</i> , 2018)
Thermal runaway mechanism of lithium ion battery for electric vehicles: A review	Energy Storage Materials	China	2018	Energy	Lithium-ion battery	(Feng <i>et al.</i> , 2018)
A review of lithium-ion battery state of charge estimation and management system in electric vehicle applications: Challenges and recommendations	Renewable and Sustainable Energy Reviews	Malaysia	2017	Energy	Lithium-ion battery	(Hannan, Lipu, <i>et al.</i> , 2017)
Enabling Localized Peer-to-Peer Electricity Trading among Plug-in Hybrid Electric Vehicles Using Consortium Blockchains	IEEE Transactions on Industrial Informatics	China	2017	Computer Science	Electricity trading model	(Kang <i>et al.</i> , 2017)
Review of energy storage systems for electric vehicle applications: Issues and challenges	Renewable and Sustainable Energy Reviews	Malaysia	2017	Energy	Energy storage system	(Hannan, Hoque, <i>et al.</i> , 2017)

In general, there has been a lot of research on electric vehicles that has been carried out globally. Both in the form of basic, development, and applied research. The high quantity of research publications over the last few years shows that each country is serious about supporting the development and use of vehicles that are more environmentally friendly. Researches engaged in engineering and energy are still quite popular, as shown in Table 1. Indonesia's position in terms of research publications related to electric vehicles is still quite behind compared to other countries.

### 3.2 Research Related to Electric Car

Based on the search using the keyword: electric AND car, obtained as many as 1,631 documents spread from 1951 to 2021. From the distribution of published years, year to year research quantity using the terminology "electric" and "car" has increased significantly, especially from 2006 to 2019. In 2010, the number of research documents on "electric" and "car" has reached more than 76 new titles, and almost touched 150 new article titles by the end of 2019. Based on the country of origin, China and the United States contributed the most in the publication of research related to "electric" and "car". Indonesia is ranked 9th as a contributor to research on "electric" and "car". Based on the three largest subject areas, 41.2% of all research are in the field of engineering field, 10.3% in the energy, and 8.3% in the field of computer science.

By using the keyword: "electric car", 1,060 documents were found (from 1951 to 2021). From the distribution of published years, year to year research quantity using the term "electric car" has increased significantly, especially in 2006 to 2011. In 2011, the number of research documents on "electric cars" has reached more than 60 new titles. Based on the country of origin, China and the United States contributed the most to research publications related to "electric cars". Indonesia is ranked 8th as a contributor to research on "electric cars". Based on the three largest subject areas, 39.8% of all research are in the engineering field, 10.3% in the energy, and 8.2% in the field of computer science.

From the search results that have been carried out, articles about electric car with the most citations in the last 5 years (2017-2021) are presented in Table 2.

Table 2. Research on Electric Car with the Most Citations (2017-2021)

Title	Source	Country	Year	Subject Area	Object of the Research	Ref.
Developments of electric cars and fuel cell hydrogen electric cars	International Journal of Hydrogen Energy	United Kingdom	2017	Energy	Electric cars and fuel cell	(Wilberforce <i>et al.</i> , 2017)
Fuel consumption optimization for smart hybrid electric vehicle during a car-following process	Mechanical Systems and Signal Processing	China	2017	Mathematics	Electric vehicle fuel	(Li, Wang and Song, 2017)
The impact of tribology on energy use and CO2 emission globally and in combustion engine and electric cars	Tribology International	Finland	2019	Energy	Electric cars emission	(Holmberg and Erdemir, 2019)
Personal Values, Green Self-identity and Electric Car Adoption	Ecological Economics	Italy	2019	Economics	Electric car adoption intention model	(Barbarossa, De Pelsmacker and Moons, 2017)
Determining optimal locations for charging stations of electric car-sharing systems under stochastic demand	Transportation Research Part B: Methodological	Austria	2017	Mathematics	Charging stations location	(Brandstätter, Kahr and Leitner, 2017)

One of the vehicle mode that is quite popularly developed and used with electric power today is the electric car. This is supported by the fact from the search results as shown in Table 2, that research on the development of electric car, battery sources, emission measurements, charging location problems, are still quite popular issues to be raised. Indonesia's position in terms of research publications related to electric cars is still quite good, because it is in the top 10 top contributor countries.

### 3.3 Research Related to Electric Bus

Based on the search using the keyword: electric AND bus, 1,644 documents were found (from 1956 to 2021). From the distribution of published years, year to year research quantity using the terminology of "electric" and "bus" has increased significantly, especially from 2006 to 2019. In 2010, the number of documents researching on "electric" and "bus" has reached more than 100 new titles, and almost reached 220 new article titles by the end of 2019. Based on the country of origin, China is the largest contributor to research publications related to "electric" and "bus", followed by the United States, Germany, and Canada. Indonesia is ranked 16th as a contributor to research on "electric" and "bus". Based on the three largest subject areas, 43% of all research in the field of engineering field, 15.3% in the energy, and 10.8% in the field of computer science.

By using the keyword: "electric bus", 1084 documents were found (from 1956 to 2021). From the distribution of published years, year to year research quantity using the term of "electric bus" has increased significantly. In 2011, the number of documents researching on "electric buses" has reached more than 60 new titles. Based on the country of origin, China and the United States contributed the most to research publications related to "electric bus". Indonesia is ranked 16th as a contributor to research on "electric bus". Based on the three largest subject areas, 41.3% of the total research titles are in the field of engineering, 15.8% in the energy, and 11.1% in the field of computer science.

From the search results that have been carried out, articles about electric bus with the most citations in the last 5 years (2017-2021) are presented in Table 3.

In addition to electric car, one of the electric vehicle mode that is quite widely developed is the electric bus. As shown in Table 3, research on electric buses is quite widely applied in various fields, not only in engineering and energy, but also in the mathematics and computer science field. Indonesia's position in terms of research publications related to electric bus is not good enough.

Table 3. Research on Electric Bus with the Most Citations (2017-2021)

Title	Source	Country	Year	Subject Area	Object of the Research	Ref.
Rule based energy management strategy for a series-parallel plug-in hybrid electric bus optimized by dynamic programming	Applied Energy	China	2017	Mathematic	Energy management strategy	(Peng, He and Xiong, 2017)
Locating charging infrastructure for electric buses in Stockholm	Transportation Research Part C: Emerging Technologies	Sweden	2017	Mathematic	Charging location	(Xylia <i>et al.</i> , 2017)
Pontryagin's Minimum Principle based model predictive control of energy management for a plug-in hybrid electric bus	Applied Energy	China	2017	Mathematic	Energy management efficiency	(Xie <i>et al.</i> , 2019)
An energy management strategy based on stochastic model predictive control for plug-in hybrid electric buses	Applied Energy	China	2017	Mathematic	Energy management strategy	(Xie, He and Peng, 2017)
Continuous reinforcement learning of energy management with deep Q network for a power split hybrid electric bus	Applied Energy	China	2018	Computer Science	Energy management	(Wu <i>et al.</i> , 2018)

### 3.4 Research Related to Electric Truck

The search results for articles on Scopus with the keyword: electric AND truck is shown in Figure 1, Figure 2, and Figure 3.

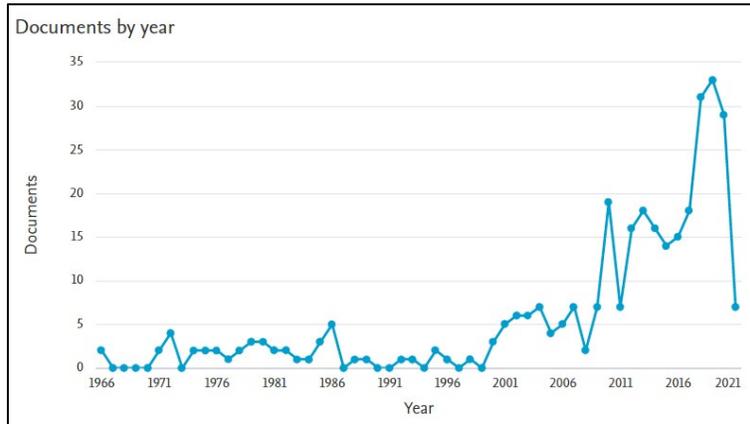


Figure 1. Research with the keyword: electric AND truck, by year

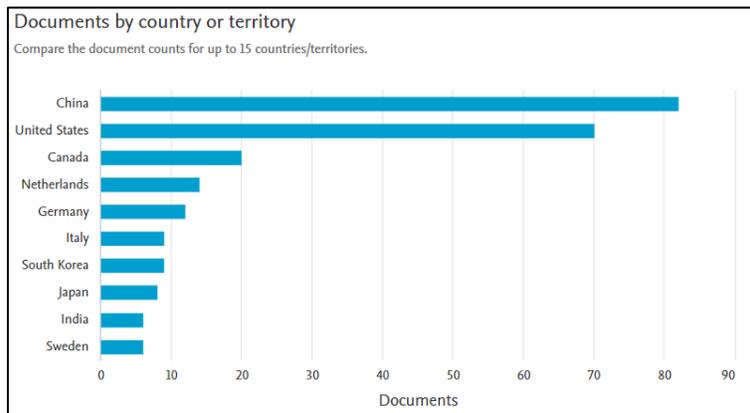


Figure 2. Research with the keyword: electric AND truck, by country of origin

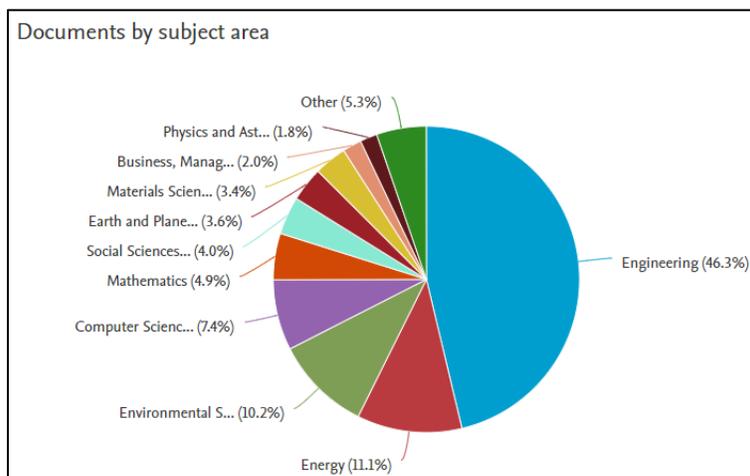


Figure 3. Research with the keyword: electric AND truck, by subject area

Based on the search using the keyword: electric AND truck, as many as 320 documents were obtained (from 1966 to 2021). From the distribution of published years, year to year research quantity using the terminology of “electric” and “truck” has increased significantly. By the end of 2019, the number of research documents on “electric” and “truck” had reached more than 30 new titles. Based on the country of origin, China and the United States contributed the most to research publications related to “electric” and “truck”. None of the article titles come from Indonesia. Based on the three largest subject areas, 46.3% of the total research titles are research in the engineering field, 11.1% in the energy field, and 10.2% in the environmental field.

The search results for articles on Scopus with the keyword: “electric truck” is shown in Figure 4, Figure 5, and Figure 6.

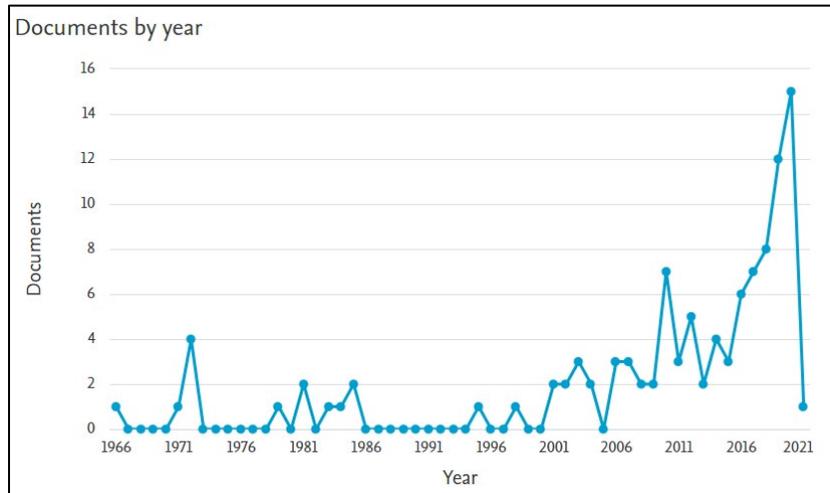


Figure 4. Research with the keyword: “electric truck”, by year

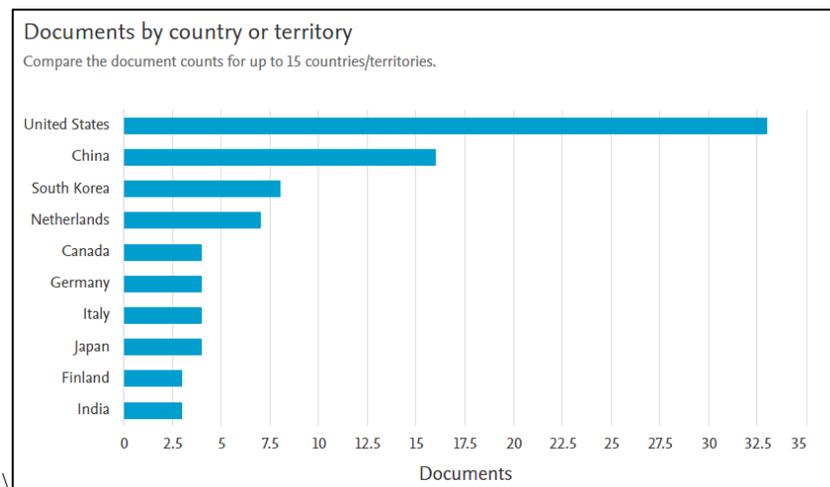


Figure 5. Research with the keyword: “electric truck”, by country of origin

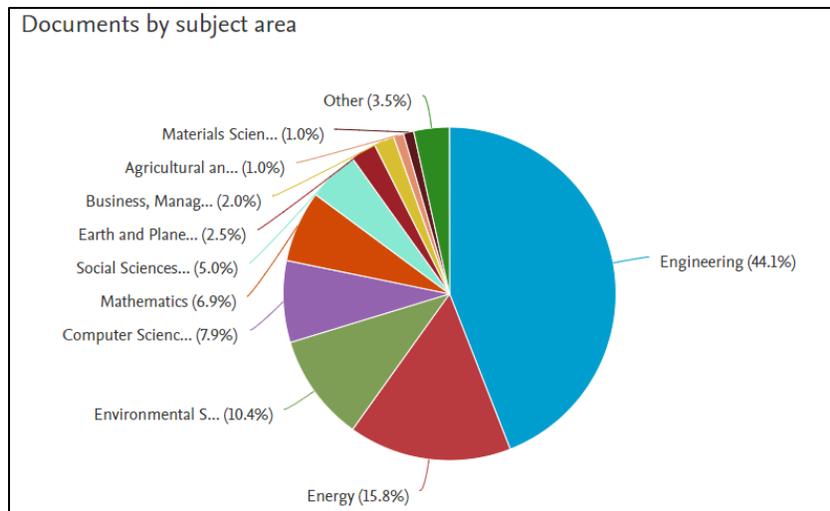


Figure 6. Research with the keyword: “electric truck”, by subject area

By using the keyword: “electric truck”, 107 documents were obtained (from 1966 to 2021). From the distribution of published years, year to year research quantity using the term of “electric truck” has increased significantly, especially during 2011 to 2020. By the end of 2020, the number of research documents on “electric trucks” had reached about 15 new titles. Based on the country of origin, the United States has the largest contribution to research publications related to electric truck, followed by China, South Korea, and the Netherlands. None of the article titles come from Indonesia. Based on the three largest subject areas, 44.1% of the total research titles are research in the engineering, 15.8% in the energy, and 10.4% in the environmental field.

From the search results that have been carried out, articles about electric truck with the most citations in the last 5 years (2017-2021) are presented in Table 4.

Table 4. Research on Electric Truck with the Most Citations (2017-2021)

Title	Source	Country	Year	Subject Area	Object of the Research	Ref.
Does a battery-electric truck make a difference? – Life cycle emissions, costs, and externality analysis of alternative fuel-powered Class 8 heavy-duty trucks in the United States	Journal of Cleaner Production	United States	2017	Engineering	Battery-electric truck	(Sen, Ercan and Tatari, 2017)
Performance Metrics Required of Next-Generation Batteries to Make a Practical Electric Semi Truck	ACS Energy Letters	United States	2017	Mathematic	Battery pack performance	(Sripad and Viswanathan, 2017)
Life-cycle implications of hydrogen fuel cell electric vehicle technology for medium- and heavy-duty trucks	Journal of Power Sources	United States	2018	Engineering	Fuel cell life-cycle	(Lee <i>et al.</i> , 2018)
Clean commercial transportation: Medium and heavy duty fuel cell electric trucks	International Journal of Hydrogen Energy	United States	2017	Engineering	Fuel cell electric trucks	(Kast <i>et al.</i> , 2017)
The potential of electric trucks – An international commodity-level analysis	Applied Energy	Finland	2019	Engineering	Electric trucks potential	(Liimatainen, van Vliet and Aplyn, 2019)

Based on the literature study in this research, not many researchers in the world have researched electric truck. This is based on the facts from the search results, where the number of publications per year is quite low. Research that discusses electric truck every year on average about 10 to 30 article titles. Based on the article search results obtained, most of the articles discuss the development of electric truck batteries, as shown in Table 4. This is relevant to the facts on the ground that one of the core problems in the development of truck electrification is related to battery development and energy management (Cameron, 2019).

Indonesia's position in the development of electric truck is very low. Based on the search results through the Scopus database, there are no article titles from Indonesia related to the development and application of research related to electric truck. This is quite interesting, considering that in searching the article database with keywords such as "electric car", "electric bus", Indonesia's position is quite good in terms of the number of publications. In 2019, the Indonesian government has issued a policy through Presidential Decree no. 55 of 2019 concerning the Acceleration of the Battery-Based Electric Motor Vehicle Program. But in the reality, there are still many researchers and practitioners who develop and apply their research in electric vehicle field that are more popular, such electric car and electric bus application. In fact, based on the data compiled by the Association of Indonesian Motor Vehicle Industries (Gaikindo), the need for truck-type vehicles in Indonesia is still quite large, in the range of 20-25% (GAIKINDO, 2021).

The search for articles related to the development of electric vehicle conversion, shows minimal results. Data searches using keywords: electric AND vehicle AND conversion (106 article titles); "electric vehicle conversion" (18 article titles); "electric truck conversion" (0 article title); and electric AND truck AND conversion (1 document result) show that not many researchers have discussed basic, applied, and development research related to the electrification of conventional vehicles.

## 6. Conclusion

One of the solutions carried out by various researchers in the world in overcoming environmental problems related to the issue of carbon emissions, the greenhouse effect, and energy saving, is by developing research related to the development and application of electric vehicles (EVs). In this study, a literature review was conducted through a database of articles related to research trends in electric vehicles in general and per mode of transportation such as cars, bus, and truck. Article searches has been conducted using certain keywords such as electric, vehicle, car, bus, truck, conversion. The results are collected and analyzed further. The search using those keywords is based on the needs in the market, where the focus of developing electric vehicles is now not only for passenger vehicles, but also for transporting goods. Based on the search results, several conclusions were obtained.

First, research trends globally have increased significantly, especially over the last 5-10 years. By using keywords such as electric, vehicle, car, bus, truck, conversion, China and the United States, and other European countries dominate the amount of research compared to other countries. This finding is supported by the fact that the trend of using electric vehicles globally, both from the number of registered vehicles and the number of vehicles on the streets, is dominated by these countries (Agency, 2021). The most widely discussed subject areas of the collected research titles are related to the fields of engineering, energy, environmental, and computer science.

Secondly, the position of the Indonesia in contributing to the number of research related to electric vehicles is still quite low compared to other countries. However, in terms of the contribution of the number of research related to electric car and electric bus, the results are quite encouraging. Regarding to the amount of research related to electric truck and electric truck conversion, both globally and in Indonesia, it is concluded that research trends in electric truck development, both in the form of new model development and conversions, are still very low. Considering that the need for the use of truck transportation modes is still widely relied on for logistics delivery, especially in Indonesia, researchers should be able to capture this opportunity in the future.

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## Biographies

**Benazir Imam Arif Muttaqin** has education background of Industrial Engineering Bachelor and Master degree from Universitas Sebelas Maret, Indonesia. Currently working as a Lecturer, as well as Head Department of Industrial Engineering, Institut Teknologi Telkom Surabaya, Indonesia. From 2020, he is member of the IEEE and IEEE Technology and Engineering Management Society. He has experience as the chief editor and journal reviewers, head of research group, as well as being a member of the internal reviewer at Institut Teknologi Telkom Surabaya. Mr. Muttaqin has completed the international certification in the field of product design; and also internal audit certification for ISO 21001:2018. He has published international journal and proceeding articles in the field of design and manufacturing system, product design and development, and quality & reliability engineering. His latest research experience includes research on solar dryer development, optimization in open pit mining, and virtual reality application in workplace design. Currently, he is involved in “conversion of diesel-powered into electric truck” research at Institut Teknologi Telkom Surabaya.

**Dominggo Bayu Baskara** works as a Lecturer at Industrial Engineering Department, Institut Teknologi Telkom Surabaya, Indonesia. Mr. Dominggo hold a Bachelor degree in Industrial Engineering and a Master degree in Management of Technology both from Institut Teknologi Sepuluh Nopember, Indonesia. He has published journal and conference papers in the fields of project management and feasibility study of new technology development. He has contributed in various new technology research projects ranging from aircraft technology, machine learning image identification, to electric vehicle conversion. Mr. Dominggo served as member of Project Management Institute (PMI). His research interests include: project management, agile method, design thinking, reverse engineering, and feasibility study.

**Miftahul Abidin** is a student in Industrial Engineering, Institut Teknologi Telkom Surabaya. His main research interest is digital technology. He is currently assisting in research of “conversion of diesel-powered into electric truck” at Institut Teknologi Telkom Surabaya. He has a high enthusiasm to develop his interests and talents.

**Hendrawan Widiyanto** is a student majoring in Industrial Engineering, Institut Teknologi Telkom Surabaya. He participated in many organizational activities on campus. Mr. Hendra has experience in assisting research on logistic system in 2020. He is currently participating in the research of “conversion of diesel-powered into electric truck” at Institut Teknologi Telkom Surabaya. His research interest is in the field of supply chain management and human resource development, statistics, and data science. He likes things that are challenging and has a high-level degree of curiosity.