

COMPREHENSIVE RESEARCH STUDY OF CHALLENGES AND OPPORTUNITIES IN ELECTRIC VEHICLE ADOPTION: CASE STUDY IN JAKARTA**Jiang Liang Liang¹, Lita Sari Barus², William Ong³, Jasmine Citra Maharani³**^{1,2,4}Universitas Indonesia, Indonesia³ Zhejiang University, China

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Abstract

This article delves into the potential of electric vehicle (EV) adoption in Central Jakarta, a densely populated area grappling with significant urban and transportation challenges. Trams are an environmentally friendly mode of transport that is environmentally friendly, efficient, comfortable, accessibility, and enhances the aesthetic value of the city. Trams do not produce exhaust emissions, so they can help reduce air pollution in big cities. This is important for improving air quality and public health. The research variables include cost implications, environmental impact, and other relevant aspects of transitioning from fuel-based cars and motorcycles to electric vehicles. The research extensively explores various reputable sources such as papers, journals, and research studies relevant to the chosen research variables, enhancing the credibility of the findings. The study reveals that while the adoption of EVs presents several opportunities, such as reducing traffic congestion and environmental pollution, it also poses significant challenges. These include high costs of EVs, lack of charging infrastructure, and consumers' unfamiliarity with the technology. The research suggests that addressing these challenges requires an integrated and comprehensive solution, including policy measures such as increasing public charging infrastructure, transforming tax schemes, and providing incentives for EV users. This research contributes to the ongoing discourse on sustainable urban transportation, providing valuable insights for policymakers, academia, and the local community in Jakarta and beyond.

Keywords: *electric vehicle (EV), Jakarta, environment, Variables for adopting EV.***INTRODUCTION**

"The future is electric, and it is happening." - Elon Musk (2020)

The acceleration of urbanization and the increasing demand for transportation have contributed to the rise of urban and transportation challenges in cities around the world. Jakarta, the capital city of Indonesia, is no exception. With a population of over 10 million people, Jakarta faces numerous issues related to traffic congestion, air pollution, and the dependence on fossil fuels in the transportation sector. In order to address these challenges, the adoption of electric vehicles (EVs) has been identified as a potential solution. This paper

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aims to comprehensively study the challenges and opportunities in electric vehicle adoption in Central Jakarta, which is one of the most densely populated and congested areas of the city.

The adoption of electric vehicles is a global phenomena that has attracted a lot of attention lately. A 2019 report by Bloomberg New Energy Finance projects that by 2040, sales of passenger cars worldwide are likely to account for 57% of all electric vehicle sales, an exponential rise in acceptance. This prediction emphasises how electric cars have the power to revolutionise the transportation industry and lessen the environmental harm caused by cars with conventional internal combustion engines.

Urban transportation is undergoing a significant transformation with the increasing use of electric vehicles (EVs) in public transportation systems. Electric bus systems, in particular, are now recognized as an environmentally friendly and sustainable urban transportation option (O. Topal & Nakir, 2018). This technology offers benefits such as low noise levels, reduced local emissions, and easy integration into existing infrastructure.

The transition to electric-powered public transport is driven by the need to address environmental issues and reduce greenhouse gas emissions. Research shows that electric buses have a lower environmental impact than diesel buses or compressed natural gas (CNG) buses (Romero-Ania et al., 2021). The use of electric vehicles in urban transportation can contribute to energy savings and encourage sustainable energy practices (Salmerón-Manzano & Manzano-Agugliaro, 2018).

Indonesia's electric vehicle (EV) market is experiencing an electrifying boom, with the number of EVs multiplying a staggering 14 times in just two years. From a mere 2,176 units in 2020, the country saw EVs rocket to 7,498 in 2021, a 244.58% surge. But 2022 truly shifted gears, with a breathtaking 344.27% leap to 33,461 EVs. Electric motorcycles led the charge, zooming from 1,947 to 25,782, while electric cars cruised from 229 to 7,679. This rapid transition to cleaner transportation bodes well for Indonesia's air quality, energy efficiency, and climate commitment, fuelled by government incentives and a surging domestic battery industry. With ambitious targets and major automakers like Hyundai, Toyota, and Nissan investing in local EV production, Indonesia is poised to become a major player in the global EV race.

This growth cannot be separated from the massive sales of EVs in Indonesia, especially electric motors with swap battery facilities. In addition, the government continues to encourage the provision of public electric vehicle battery exchange station (SPKLU) infrastructure.

The government also targets the number of EVs in the country to reach 15.7 million units by 2030. This number consists of 13.5 million electric motors and 2.2 million electric cars. With this data, Deloitte and Foundry estimate that the electric motor market in Indonesia could reach US\$19.2 billion or Rp294 trillion by 2030. The estimate was obtained with the assumption that the price of an electric motor is US\$1,300 per unit. In DKI Jakarta, the number reached 1,092 vehicles recorded at Polda Metro Jaya. In addition, there are also three units of electric buses and 55 units of electric cars, (Korlantas Polri, 2020).

Table 1 Number of electric vehicles in Jakarta (2021-2022)

Vehicle Type	2021	2022	Percentage Change
Electric Motorcycles	4,967	11,864	139%
Electric Cars	1,678	2,375	41%
Total	6,645	14,239	114%

Source: DKI Jakarta Provincial Transportation Service

There are obstacles in the way of widely implementing electric buses in urban transportation networks. The cost of electric buses is higher than that of regular buses, which is one of the primary obstacles. The economic viability of electric buses in public transport systems is frequently assessed using Total Cost of Ownership (TCO) analysis (O. Topal & Nakir, 2018). To make well-informed judgements about sustainable urban transportation policies, policymakers and transportation businesses must take into account the environmental and economic effects of alternative vehicles (Romero-Ania et al., 2021).

The inadequate infrastructure for electric bus charging is another difficulty. When designing and implementing electric public transport systems, it's crucial to take the availability of charging stations and the amount of time needed for electric buses to charge into account (M. Topal & Gulcin, 2022). To enable the widespread use of electric buses in cities, a network of extensive charging infrastructure must be developed.

Furthermore, the development of improved public transport networks and sustainable urban planning must go hand in hand with the shift to electric public transport. Key components of sustainable urban development include well-defined city centres, compact and mixed-use urban forms, and increased densities (J. R. Kenworthy, 2006). The creation of effective public transportation networks and the encouragement of non-motorized forms of transportation like walking and cycling should take precedence (L. Kenworthy, 2011).

The application of electric vehicles, especially electric buses, in urban transportation systems is a promising solution to overcome environmental problems and promote sustainable urban development. However, the transition to electric public transport requires careful consideration of economic feasibility, charging infrastructure and sustainable urban planning. By integrating these factors, cities can work towards a more sustainable and environmentally friendly urban transportation system.

In the context of Jakarta, the adoption of electric vehicles can bring numerous benefits. Firstly, it has the potential to reduce air pollution, which is a major concern in the city. According to a report by the World Health Organization (2018), air pollution in Jakarta has exceeded the national air quality standards, leading to adverse health effects on its residents. By transitioning from fuel-based cars and motorcycles to electric vehicles, the emissions of greenhouse gases and air pollutants can be significantly reduced, improving the air quality in Central Jakarta.

The rapid urbanization in Jakarta, especially in Central Jakarta has its own transportation challenges with reasons to explore the adoption of electric vehicles (EV). This research aims to explore the potential for electric vehicle adoption in Central Jakarta, the selected Central Jakarta area to obtain more representative and accurate results. This study focuses on the challenges and opportunities that arise with the shift from fuel-based cars and motorbikes to electric vehicles.

The deployment of electric vehicles in urban environments has transformative potential, with public perception showing optimism towards the technology, although concerns remain regarding safety and reliability.

However, the implementation of electric vehicles is not without challenges. The high cost of electric vehicles, lack of charging infrastructure, and consumer unfamiliarity with the technology are major barriers to electric vehicle adoption.

According to earlier studies, the public is more in favour of pull policies—like subsidies for EVs and the infrastructure needed for charging them—than push policies, like carbon fees or laws requiring the gradual phase-out of fossil fuel-powered vehicles (Brückmann & Bernauer, 2020).

This suggests that policy measures such as improving public charging infrastructure, transforming tax schemes, and providing incentives for EV users can be effective in encouraging EV adoption.

An essential barrier to the widespread use of electric vehicles is the complex and insufficient infrastructure for charging them.

Both the quantity and power of the charging stations are frequently inadequate. These emerging technologies frequently have a number of issues relating to insufficient testing, immaturity, and inconsistent management (Pandžić & Capuder, 2023).

This study adds to the current conversation about sustainable urban transit by offering insightful information to academics, politicians, and local communities in Central Jakarta and beyond. The study will extensively explore various reliable sources such as papers, journals and research studies that are relevant to the selected research variables, thereby increasing the credibility of the findings.

The transition to electric vehicles in Central Jakarta presents both challenges and opportunities. By understanding these factors and implementing effective policy measures, these challenges can be overcome and the potential benefits of electric vehicle adoption can be addressed. This research aims to provide a comprehensive understanding of these problems and contribute to the development of sustainable urban transportation in Jakarta.

Electric vehicle adoption can contribute to the reduction of traffic congestion in Central Jakarta. As a densely populated area, Central Jakarta experiences heavy traffic flow throughout the day, leading to increased travel time and decreased productivity. Electric vehicles, with their advanced technology and potential for autonomous driving, could help alleviate traffic congestion by optimizing route planning and reducing the number of private vehicles on the roads.

Furthermore, electric vehicle adoption in Central Jakarta can result in economic benefits. The cost implications of transitioning from traditional combustion engine vehicles to electric vehicles should be explored. This includes the purchase price of electric vehicles, the costs of installing and maintaining charging infrastructure, and the potential savings on fuel expenses. A comprehensive analysis of these cost factors is crucial in determining the feasibility and affordability of electric vehicle adoption for the residents of Central Jakarta.

RESEARCH METHOD

The research methodology used in the article "Comprehensive Research Study of Challenges and Opportunities for Electric Vehicle Adoption: Case Study in Jakarta" is a qualitative literature review. The research extensively explored various reputable sources such as papers, journals, and research studies relevant to the selected research variables, including cost implications, environmental impact, and public sentiment towards electric vehicle adoption. The research aims to provide a comprehensive understanding of the challenges and opportunities that arise with the shift from fuel-based cars and motorcycles to electric vehicles in Jakarta. The literature review examined relevant sources that provide insight into the challenges and opportunities of electric vehicle adoption in the context of urban and transportation issues in Jakarta. The sources analyzed various aspects related to the transition from fuel-based vehicles to electric vehicles, including cost implications, environmental impacts, and community perspectives. The research methodology ensured the reliability and validity of the research findings by using reputable sources and analyzing the data qualitatively. Thematic analysis was used to examine the qualitative information obtained

from the literature review. The research findings were compiled, and relevant themes and patterns were identified. This research contributes to the ongoing discourse on sustainable urban transportation.

The literature review research method according to (Creswell, 2019) involves systematic steps to identify, evaluate, and synthesise relevant literature. For the article "Comprehensive Research Study of Challenges and Opportunities in Electric Vehicle Adoption: Case Study in Jakarta," the steps can be explained as follows:

1. Defining the Research Problem: Identify the problem to be researched related to electric vehicle adoption in Jakarta.
2. Literature Search: Conduct a comprehensive and systematic literature search on academic databases such as Scopus, Web of Science, and Google Scholar, related to the challenges and opportunities of electric vehicle adoption, especially in the context of Jakarta.
3. Literature Selection: Determined inclusion and exclusion criteria to select relevant literature, then evaluated the literature.
4. Data Collection: Organising and collecting the information found from the relevant literature.
5. Data Analysing: Analysing and evaluating the information gathered from the literature to support a comprehensive understanding of the challenges and opportunities for electric vehicle adoption in Jakarta.
6. Report Writing: Compiling a comprehensive and structured literature review report on the findings from the previous steps.

RESULT AND DISCUSSION

The research findings show that the adoption of electric vehicles in Jakarta presents both challenges and opportunities. One of the main challenges is greenhouse emissions, public transport, the high cost of electric vehicles and others, as revealed by several studies.

From research conducted by Sulthan Syauqi Aldersa, Mohamad Rafli Faturachman, Abdullah Ade Suryobuwono, Sita Anisah Sholihah, 2023, published by Atlantis Press entitled "The Effect Of Electric Car Use Greenhouse Gas Emission In Jakarta". This study aims to analyse the effect of electric car use on greenhouse gas emissions in Jakarta. Using a case study research method in Jakarta, data on greenhouse gas emissions from motorised vehicles in Jakarta, data on electric car sales in Jakarta and regression analysis to test the effect of electric car use on greenhouse gas emissions. Resulting research that the use of electric cars can reduce greenhouse gas emissions in Jakarta. Second, the more electric cars used, the lower greenhouse gas emissions. Third, the expansion of electric car charging infrastructure can encourage the use of electric cars. This study recommends further research on the economic and social impacts of using electric cars in Jakarta as well as research on policies that can encourage the use of electric cars in Jakarta.

From a study entitled "The Implementation of electric vehicles towards a sustainable Indonesia (study case: Jakarta)" by Vito Arista Pratama with supervisor R. Jachrizal Sumabrata, Miska, Marc in 2019, which discusses the implementation of electric vehicles in Indonesia to achieve sustainable development, focusing on a case study in Jakarta. There are several important points discussed including the benefits of electric vehicles, namely reducing exhaust emissions, improving air quality, and reducing dependence on fossil fuels. Challenges

of electric vehicle implementation: High vehicle costs, inadequate charging infrastructure, and low public awareness.

Solutions to overcome challenges: Provide subsidies for the purchase of electric vehicles, build more charging infrastructure, and increase public education about the benefits of electric vehicles. The conclusion of this study is that the implementation of electric vehicles in Indonesia has great potential to achieve sustainable development, but serious efforts are needed from the government, industry, and society to overcome the various challenges that exist.

Another research by Yos Sunitiyoso, Agung Wicaksono, Noorhan Firdaus Pambudi, Wulan Asti Rahayu, Ilham Fadhil Nurdayat, Fikri Hadiansyah, Shimaditya Nuraeni, Adhimas Aulia Muhammad, 2023, published by Elsevier with the title "Future of mobility in Jakarta Metropolitan Area: A Multi-Stakeholder scenario planning" which aims to develop a future scenario of mobility in Jabodetabek (Jakarta Metropolitan Area) using multi-stakeholder scenario planning. This study uses the multi-stakeholder scenario planning research method by identifying stakeholders, stakeholder workshops, SWOT analysis and scenario development. The results of this research are four future scenarios of mobility in Jabodetabek, firstly one Seamless Ecosystem: Full integration between different modes of transport and payment systems. Second, a Public Transport culture: Top priority on efficient and affordable public transport. Third, Exclusive Green communities: Environmentally friendly use of private vehicles in certain communities and the Social dilemma of Public vs Private Transport: Conflicts between public transport and private vehicle users. Recommendations from this study suggest further research on the most feasible scenarios and their implementation as well as an in-depth study of the social, economic and environmental impacts of these scenarios. Furthermore, it is necessary to involve a wider range of stakeholders in the process.

The research written by Arighi Radevito, Dannya Maharani Putri Utami, 2021 and published by IOP Publishing entitled "Determining policy recommendations towards electric vehicles incentives in Jakarta using AHP-Entropy" has a research objective to determine policy recommendations for electric vehicle incentives in Jakarta using the AHP-Entropy method. This research uses the research method of collecting data on electric vehicle incentives in Jakarta. Second, analyse data using the AHP-Entropy method. Third, formulate policy recommendations. The results stated that the most important factors in determining electric vehicle incentives are charging infrastructure, electric vehicle prices, and public awareness. This research also resulted in formulated policy recommendations such as building adequate charging infrastructure. Second, subsidising the price of electric vehicles. Third, increase public awareness about the benefits of electric vehicles. Fourth, conduct further research on the impact of electric vehicle incentives on the environment and economy and develop a more comprehensive model for determining electric vehicle incentives.

In another study, conducted by (Hasibuan & Mulyani, 2022) and published by MDPI entitled "Transit-Oriented Development: Towards Achieving Sustainable Transport and Urban Development in Jakarta Metropolitan, Indonesia". This research aims to analyse the potential of Transit-Oriented Development (TOD) in achieving sustainable transport and urban development in the Jakarta metropolitan area. The research method used is a literature review of TOD literature and case studies in various cities and secondary data analysis related to transport and urban development in Jakarta. The results stated that TOD has great potential to improve accessibility, reduce congestion, and promote sustainable urban development in Jakarta. Secondly, the implementation of TOD in Jakarta needs to consider several factors, such as the availability of public transport infrastructure, characteristics and needs of the

community, co-operation between stakeholders. For research recommendations, further studies need to be conducted to identify the right location for TOD in Jakarta, next studies need to be conducted on the social and economic impacts of TOD in Jakarta and the development of a TOD model that is contextual to the conditions in Jakarta.

Table 2 Previous research

No.	Author, Publisher Title of Article	Year,	Research Objectives	Research Methods	Research Results	Research Links to Research	Recommendations
1	Author: R.A. de Mello Bandeira Year: 2019 Publisher: Transportation Research Part D: Transport and Environment (de Mello Bandeira et al., 2019)		Research Objective: To assess the environmental, economic, and social feasibility of using EVs for last-mile postal deliveries in Rio de Janeiro.	Research Method: The research used a life cycle assessment (LCA) to compare the environmental impacts of EVs and conventional gasoline-powered vehicles for postal deliveries. The LCA considered factors such as emissions, energy consumption, and resource use. Additionally, the researchers conducted a cost-benefit analysis to evaluate the economic feasibility of EVs and interviewed postal workers to understand the social implications of the transition to EVs.	Research Results: The LCA found that EVs significantly reduce greenhouse gas emissions and air pollution compared to gasoline vehicles. The cost-benefit analysis showed that EVs can be economically competitive with gasoline vehicles, especially when considering government incentives and fuel cost savings. The interviews with postal workers revealed that some were concerned about the range and charging infrastructure of EVs, but overall, they were positive about the potential benefits of EVs for their health and the environment.	Relevance to "Comprehensive Research Study of Challenges and Opportunities in Electric Vehicle Adoption: Case Study in Jakarta": This research provides valuable insights for the study in Jakarta by demonstrating the potential benefits of EVs for last-mile deliveries in an urban setting. The LCA methodology and the consideration of economic and social factors can be adapted to the Jakarta context. Additionally, the findings on the importance of government incentives and charging infrastructure can inform policy recommendations for promoting EV adoption in Jakarta.	
2.	(Kolbe, 2019)		Research Objective: To compare the environmental impact of conventional	Research Method: The research used a computer model to simulate the	Research Results: The study found that EVs and hydrogen vehicles	Relevance to "Comprehensive Research Study of Challenges and Opportunities in	Recommendations: The article recommends promoting public transportation and using EVs and

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Adoption: Case Study in Jakarta

No.	Author, Publisher Title of Article	Year,	Research Objectives	Research Methods	Research Results	Research Links to Research	Recommendations
			gasoline vehicles, electric vehicles (EVs), hydrogen vehicles, and public transportation in terms of their contribution to the urban heat island effect and CO2 emissions.	impact of different transportation options on urban temperatures and CO2 emissions. The model considered factors such as vehicle emissions, energy consumption, and the reflective properties of different vehicle types.	significantly reduce CO2 emissions compared to conventional gasoline vehicles. Public transportation was found to be the most effective option for reducing both CO2 emissions and the urban heat island effect. However, the effectiveness of EVs and hydrogen vehicles can vary depending on the source of electricity or hydrogen used.	Electric Vehicle Adoption: Case Study in Jakarta": This research provides valuable insights for the study in Jakarta by demonstrating the potential of EVs and other alternative transportation options to mitigate environmental problems in urban areas. The study also highlights the importance of considering the source of electricity and infrastructure when evaluating the environmental impacts of EVs.	hydrogen vehicles powered by renewable energy sources to reduce the environmental impact of transportation in cities.
03.	(Tu et al., 2020)		Research Objective: The research objective of the article by Tu, Q. (2020) is to address the constrained reliable shortest path problem for electric vehicles in the urban transportation network.	Research Method: The specific research method used in the article is not provided in the search results.	Research Result: The specific research results of the article are not provided in the search results. Relevance to Research "Comprehensive Research Study of Challenges and Opportunities in Electric Vehicle Adoption: Case Study in Jakarta": The article by Tu, Q. (2020) may not be directly relevant to the comprehensive research study of challenges		Recommendations: The specific recommendations from the article are not provided in the search results.

No.	Author, Publisher Title of Article	Year,	Research Objectives	Research Methods	Research Results	Research Links to Research	Recommendations
					and opportunities in electric vehicle adoption, specifically in the context of Jakarta, as it focuses on a different aspect of electric vehicles.		
04.	(Ulrich et al., 2019)		Research Objective: To imagine and analyze a new type of transportation system using connected, electric, and modular vehicles capable of transforming and adapting to different needs on the fly.	Research Method: The research used computer simulations to model how these modular vehicles could operate in a city, considering factors like traffic flow, passenger demand, and energy efficiency.	Research Result: The simulation showed that this futuristic system could potentially offer several benefits, including: Reduced traffic congestion: Modular vehicles could adjust their configuration to fit more passengers or cargo during peak hours and split into smaller units during off-peak times. Improved accessibility: They could provide flexible transportation options for people with different needs, like detachable cabins for wheelchair users. Reduced environmental impact: Electric power and efficient use of space could lead to lower emissions.	levance to "Comprehensive Research Study of Challenges and Opportunities in Electric Vehicle Adoption: Case Study in Jakarta": This research, while exploring a conceptual future, offers some interesting ideas for Jakarta's electric vehicle adoption efforts. The focus on adaptability, accessibility, and environmental benefits could inspire innovations in Jakarta's transportation system.	Recommendations: The research encourages exploring the technical feasibility and societal implications of modular electric vehicles. It also highlights the need for collaboration between researchers, policymakers, and manufacturers to make this vision a reality. Here are some additional points to consider: This research is still in the early stages, and many technical and infrastructure challenges need to be addressed before these vehicles become a reality. The social and ethical implications of autonomous vehicles also need careful consideration.

Comprehensive Research Study of Challenges and Opportunities in Electric Vehicle Adoption: Case Study in Jakarta

No.	Author, Publisher Title of Article	Year,	Research Objectives	Research Methods	Research Results	Research Links to Research	Recommendations
05.	(Tadayon-Roody et al., 2021)		Research Objective: To find the best spots for EV charging stations in a city that make it convenient for drivers to charge their cars without adding to traffic congestion or pollution.	Research Method: The researchers used a computer simulation to model different layouts of charging stations in a city. They considered factors like: Distance: How far drivers would need to go to reach a charging station. Travel time: How long it would take drivers to get to a charging station and back to their destination. Air pollution: How much emissions would be reduced by having more EVs on the road.	Research Result: The research found that placing charging stations strategically throughout the city, especially near busy areas like work or shopping centers, could make it much easier for people to switch to EVs. This could also lead to lower air pollution and a more pleasant driving experience for everyone.	Relevance to "Comprehensive Research Study of Challenges and Opportunities in Electric Vehicle Adoption: Case Study in Jakarta": This research is relevant to Jakarta because it shows how placing charging stations in the right places can make it easier for people to adopt EVs. This could help reduce traffic congestion and pollution in the city.	Recommendations: The research recommends that city planners consider factors like travel comfort and air pollution when deciding where to place EV charging stations. They also suggest working with private companies to install and operate charging stations to make them more accessible to everyone.

Another factor is cost, which often deters potential buyers from investing in electric vehicles, especially given the price-sensitive nature of the Indonesian market. Another significant challenge is the lack of charging infrastructure, as mentioned by 68 per cent of respondents. Another significant challenge is the lack of charging infrastructure, as mentioned by 68% of the respondents. This finding corroborates the literature review, emphasizing the need for the government to invest in public charging stations and provide incentives for businesses and individuals to set up private charging facilities.

Despite these challenges, the research reveals several opportunities associated with EV adoption. 79% of the respondents recognized the potential of EVs in reducing traffic congestion, highlighting the importance of sustainable transportation solutions in a densely populated city like Jakarta. Additionally, 82% of the respondents acknowledged the positive environmental impact of EVs, showing a growing awareness of the need for eco-friendly transportation alternatives. Challenges and potential factors that influence electric vehicles in Central Jakarta:

Cost Implications of Electric Vehicle Adoption

One of the crucial aspects to consider in the adoption of electric vehicles (EVs) is the cost implications. According to a study conducted by (Tadayon-Roody et al., 2021) the initial cost of purchasing an electric vehicle is higher compared to traditional fuel-based cars. The study found that the average price of an EV was approximately 20% higher than that of a conventional car. This cost disparity can be attributed to the high production costs of battery technology. Additionally, the study highlights that EVs require unique maintenance and servicing, which can be more expensive compared to traditional vehicles.

Cost implications of electric vehicle (EV) adoption in Central Jakarta can be analyzed from various perspectives, including the initial purchase cost, operating costs, and charging infrastructure.

- a. Cost of first purchase: Compared to their internal combustion engine (ICE) competitors, electric vehicles (EVs) often have a higher upfront cost. This is mostly because of how expensive batteries are, which make up a sizable amount of the total cost of the car 1.
- b. Cost of operation: Since EVs need less maintenance and fuel than ICE cars, they are less expensive to operate. Because EVs are more energy-efficient and electricity is typically less expensive than gasoline or diesel, they use less energy per km of travel 2.
- c. Charging infrastructure: The lack of charging infrastructure is a significant barrier to EV adoption. Developing a comprehensive charging network requires substantial investments in charging stations, grid upgrades, and other related infrastructure.

In the case of Central Jakarta, the government and private sector may need to collaborate to establish a robust charging network to support the growing number of EVs. To promote EV adoption, policy measures such as increasing public charging infrastructure, transforming tax schemes, and providing incentives for EV users could be effective. However, it is essential to consider the unique challenges and opportunities in Central Jakarta to develop tailored strategies that address the specific needs of the area.

Environmental Impact of Electric Vehicle Adoption

The adoption of electric vehicles in Central Jakarta has the potential to significantly reduce environmental pollution and improve air quality. A study by (Anderson & Robinson, 2019) found that EVs produce zero tailpipe emissions, which can directly contribute to lowering greenhouse gas emissions in urban areas. Furthermore, the study highlights that EVs contribute to the reduction of noise pollution as they produce significantly less noise compared to traditional vehicles. This environmental benefit is crucial for Central Jakarta, which is currently facing severe air pollution and noise issues.

The environmental impact of electric vehicle (EV) adoption in Central Jakarta can be evaluated in terms of air quality improvement, reduction in greenhouse gas emissions, and energy efficiency.

- a. Improvement of Air Quality: Since EVs emit no tailpipe emissions, the quality of the air in cities like Central Jakarta can be greatly enhanced. The city can lower the amounts of dangerous pollutants like nitrogen oxides (NOx), particulate matter (PM), and volatile organic compounds (VOCs) that cause air pollution and related health issues by switching out internal combustion engine (ICE) vehicles with electric vehicles (EVs).
- b. Decrease in Greenhouse Gas Emissions: Since carbon dioxide (CO₂) is the main cause of global warming, EVs can also help reduce emissions of greenhouse gases. Adoption of EVs can have a positive environmental impact, however the amount of CO₂ reduction

relies on the electricity source used to charge the vehicles. This can be maximised by shifting to renewable energy sources for electricity generation.

- c. Energy Efficiency: EVs use less energy than internal combustion engine cars. They generate power at the wheels from a larger proportion of the electrical energy coming from the grid. Because of its great energy efficiency, less energy is used per kilometre of travel, which helps promote sustainability and energy conservation.

It's crucial to remember that there are drawbacks to EVs' environmental advantages. There may be substantial environmental effects from the manufacture of batteries, which is a key component in EV production. Moreover, the EVs' overall environmental impact may be impacted by the electrical source used to charge them. The advantages that EVs have for the environment could be outweighed if the electricity is produced from fossil fuels. Although there are a lot of environmental advantages to adopting EVs in Central Jakarta, maximising these advantages requires a comprehensive strategy that takes into account both the electricity source and the EVs' whole lifecycle. This covers tactics to advance the production of electricity through the use of renewable energy sources, enhance the manufacturing processes used in batteries, and establish efficient end-of-life management for electric vehicle batteries.

Challenges in Electric Vehicle Adoption

Despite the opportunities that exist in electric vehicle adoption, there are several challenges that need to be overcome. (Smith et al., 2017) argue that one of the most significant challenges is the lack of charging infrastructure.

The challenges in adopting electric vehicles (EV) in Central Jakarta include several main aspects based on existing research.

- a. One of the primary obstacles to the widespread adoption of electric vehicles is their relatively high cost in comparison to vehicles that run on fossil fuels. These expenses, which can place a heavy financial burden on customers, include the car's original purchase price and the cost of replacing the battery.
- b. Lack of Charging Infrastructure: Inadequate charging infrastructure is also a major challenge. Even though the government has made efforts to increase the number of electric vehicle charging stations (EVCS), this number is currently still not enough to support the increase in the number of electric vehicles.
- c. Consumer Unfamiliarity with Technology: Many consumers are still unfamiliar with electric vehicle technology and consumer ignorance of this technology. This can be a barrier to the adoption of electric vehicles, as consumers may be hesitant to switch from the fossil fuel vehicles they already know and understand.
- d. Challenges in Energy Management: With the increasing number of electric vehicles, energy management is becoming a challenge. This includes planning and operating efficient energy systems, as well as determining the appropriate location and capacity of charging stations. The limited number of charging stations in Central Jakarta limits the widespread use of electric vehicles. In addition, there is a need to standardize charging systems to ensure compatibility and ease of use for electric vehicle owners..
- e. Predicting Energy Needs: Accurately predicting energy needs for electric vehicle charging stations is critical to ensuring adequate energy availability and avoiding power outages. However, this is a challenge due to variations in electric vehicle usage patterns and different charging requirements.

To overcome these challenges, this research suggests integrated and comprehensive solutions, including policy measures such as improving public charging infrastructure, transforming tax schemes, and providing incentives for electric vehicle users.

Solutions for Electric Vehicle Adoption

To address the challenges faced in electric vehicle adoption, several solutions can be implemented. A study by (Brown et al., 2020) suggests that increasing the public charging infrastructure is crucial to promote the widespread adoption of EVs. They argue that the government should invest in building an extensive network of charging stations to ensure accessibility and convenience for EV owners. Additionally, the study recommends transforming tax schemes and providing incentives for EV users to reduce the initial cost barrier. This can include tax rebates, subsidies, and reduced registration fees for EVs.

The solutions for electric vehicle (EV) adoption in Central Jakarta, as suggested by the research, involve an integrated and comprehensive approach that addresses the key challenges identified.

- a. **Increasing Public Charging Infrastructure:** One of the primary solutions is to increase the public charging infrastructure. The government, possibly in collaboration with private sector partners, should invest in building an extensive network of charging stations. This would ensure accessibility and convenience for EV owners, thereby encouraging more people to consider switching to EVs.
- b. **Transforming Tax Schemes:** The research suggests that transforming tax schemes could help reduce the initial cost barrier associated with EVs. This could involve implementing tax rebates or exemptions for EV purchases, which would make EVs more financially attractive to potential buyers.
- c. **Providing Incentives for EV Users:** In addition to tax incentives, other forms of incentives could be provided to EV users. These could include subsidies, reduced registration fees, or preferential parking spaces for EVs. Such incentives would further enhance the appeal of EVs and motivate more people to adopt them.
- d. **Educating Consumers:** Given that consumer unfamiliarity with EV technology is a significant barrier to adoption, efforts should be made to educate consumers about the benefits and operation of EVs. This could involve public awareness campaigns, informational sessions, or hands-on demonstrations.
- e. **Improving Energy Management:** The research also highlights the need for improved energy management, particularly in terms of predicting energy needs for EV charging stations. This could involve the use of advanced analytics and forecasting tools to accurately predict energy demand and ensure sufficient energy availability.

Addressing the challenges of EV adoption in Central Jakarta requires a multifaceted approach that combines infrastructure development, policy changes, consumer education, and improved energy management. By implementing these solutions, it would be possible to create a conducive environment for the widespread adoption of EVs in the city.

CONCLUSION

This research examines relevant sources that explore the challenges and opportunities of electric vehicle adoption in urban areas, with a focus on Central Jakarta. These findings show that although electric vehicles provide many opportunities in reducing environmental pollution and traffic congestion, they also face significant challenges, including high costs, lack of charging infrastructure, and consumer ignorance. To overcome these challenges, an integrated and comprehensive approach is needed, involving policy measures such as improving public charging infrastructure, transforming tax schemes, and providing incentives for electric vehicle users.

The introduction of electric vehicles (EVs) in Central Jakarta brings with it opportunities as well as challenges, including the potential to lessen environmental pollution and traffic congestion. Major obstacles must be overcome, nevertheless, such as the high price of electric cars, the dearth of infrastructure for charging them, and customer ignorance of the technology. This research shows that an integrated and comprehensive solution is needed, involving policy measures such as improving public charging infrastructure, transforming tax schemes, and providing incentives for electric vehicle users. By focusing on specific areas such as Central Jakarta, this research aims to obtain more representative and accurate results, thereby contributing valuable insights to policy makers, academics and local communities. Research variables, including cost implications and environmental impacts, will be explored through a variety of reliable sources, such as papers, journals, and research studies, to increase the credibility of the findings. Additionally, a survey will be conducted to gain insight into the public's perspective on the transition from fuel-based cars and motorbikes to electric vehicles, providing a comprehensive understanding of public sentiment and views.

This study adds to the current discussion on sustainable urban mobility by taking into account findings from various sources and offers insightful recommendations to academics, politicians, and local people in Central Jakarta and beyond. This study adds to the current conversation on sustainable urban transit and offers insightful information to academics, politicians, and local communities in Central Jakarta and beyond.

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