Jurnal Ekonomi, Manajemen Pariwisata dan Perhotelan
Volume 5, Nomor 1, Januari 2026
E-ISSN: 2809-6037, P-ISSN: 2809-5901, Hal. 617-636
DOI: https://doi.org/10.55606/jempper.v5i1.6017
Tersedia: https://journalcenter.org/index.php/jempper

Analyzing the Effectiveness of Electric Vehicles in Indonesia

A Malthusian Approach to Resource and Emission Management

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Abstract. *This research will explore some of the best solutions to global warming through the perspective of electric vehicles. The methodology will be a mix of survey methods, case studies comparing Indonesia and Singapore, and interviews with experts to understand public perception, analyze real examples, and garner expert views. The findings indicate significant barriers towards the adoption of EVs in Indonesia due to inadequate charging infrastructure, high costs, and range anxiety; Singapore, through urban challenges coupled with government policies, has a high rate of adoption. It is clear that technological advancements in EVs themselves, charging infrastructure, and policy frameworks will have to be in place for greater adoptions to be encouraged. Key recommendations include cultivating natural demand through consumer awareness campaigns, government incentives, and integration of renewable energy sources into charging infrastructure. Though there are limitations to this study, the findings provide valuable additions to the ongoing discourse on sustainable transportation and climate change mitigation in developing countries.*

Keywords: *Charging Infrastructure; EVs; Global Warming; Malthus; Public Perception.*

1. INTRODUCTION

Global warming is a pressing global issue with far-reaching consequences, including rising sea levels, habitat destruction, and severe climate changes. Indonesia, as one of the largest archipelagic countries, is particularly vulnerable to these effects. For instance, Jakarta, Indonesia's capital, is sinking at an alarming rate due to rising sea levels and excessive groundwater extraction (Lin & Hidayat, 2018). The nation’s rich biodiversity is under threat as ecosystems, such as mangrove forests, face degradation due to higher temperatures and changing rainfall patterns. Moreover, Indonesia is among the world's largest greenhouse gas emitters, with transportation being a significant contributor. In 2022, the sector accounted for 28% of the nation's total emissions (Environmental Protection Agency [EPA], 2022).

One proposed solution to mitigate these emissions is the adoption of electric vehicles (EVs). EVs are touted as an environmentally friendly alternative to conventional gasoline-powered vehicles, with manufacturers claiming they reduce carbon footprints and improve air quality (Markus, 2023). In Indonesia, the government has launched initiatives to promote EVs, such as tax incentives and the development of charging infrastructure. However, despite these efforts, challenges persist. The country’s reliance on coal for electricity generation undermines the environmental benefits of EVs, as the energy used to charge these vehicles often comes from non-renewable sources. Additionally, concerns about battery production, waste management, and the

Naskah Masuk: 21 Oktober 2025; Revisi: 15 November 2025; Diterima: 07 Desember 2025; Tersedia: 09 Desember 2025.

cost of EV adoption remain significant barriers.

The root cause of Indonesia's contribution to global warming lies in its energy and transportation systems. The heavy dependence on fossil fuels for energy generation and the dominance of gasoline-powered vehicles exacerbate emissions. This challenge is compounded by Indonesia's growing population and urbanization, which increase energy and transportation demands. Thomas Malthus' theory on the relationship between population and resources underscores the urgency of addressing these systemic issues. Malthus argued that unchecked population growth could surpass resource availability (Donald G., n.d.), a scenario that mirrors Indonesia's struggle to balance development with environmental sustainability.

Various efforts have been undertaken to address these challenges. The Indonesian government has implemented policies to encourage renewable energy adoption, such as the development of solar and wind farms. Public transportation initiatives, including the construction of the MRT and LRT systems, aim to reduce reliance on private vehicles. However, these solutions face limitations. Renewable energy projects are hindered by high costs and limited capacity, while public transportation systems often encounter delays and require substantial upfront investments that temporarily impact local environments (Gordon, 2023; EPA, 2022).

Furthermore, recycling and waste management systems in Indonesia remain underdeveloped, reducing the effectiveness of initiatives to mitigate the environmental impact of EV batteries and other pollutants.

This thesis seeks to explore the effectiveness of electric vehicles as a strategy to combat global warming in Indonesia. It aims to analyze the environmental, economic, and social implications of EV adoption and propose actionable recommendations tailored to the Indonesian context. By evaluating the limitations of existing approaches and incorporating Malthus' perspective on resource dynamics, this study will provide a comprehensive framework to address Indonesia's specific challenges in reducing greenhouse gas emissions.

The findings of this thesis are expected to offer significant benefits. Policymakers will gain insights into optimizing EV-related policies to maximize their environmental impact. Industries can better understand the opportunities and challenges associated with transitioning to EV production and usage. Furthermore, this research will contribute to the broader discourse on sustainable development by offering solutions that balance environmental protection with economic growth. Ultimately, this thesis aims to support Indonesia's commitment to achieving its climate goals,

including reducing greenhouse gas emissions by 29% by 2030, as outlined in its Nationally Determined Contributions (NDCs).

Electric vehicles have great potential to help mitigate global warming, but their effectiveness is currently hindered by technological limitations, implementation challenges, and insufficient infrastructure. To fully realize their potential in combating global warming, it is essential to optimize electric vehicle technology, address the challenges of implementation, and develop the necessary supporting infrastructure.

2. LITERATURE REVIEW

Thomas Malthus (1766–1834), an English demographer and economist, is best known for his theory of population growth and its implications on resources. Born into a prosperous family deeply influenced by Enlightenment thought, Malthus' ideas were shaped by his education, his exposure to contemporary debates, and his empirical observations of the socioeconomic conditions of his time. His father, Daniel Malthus, was an admirer of Jean-Jacques Rousseau and a proponent of progressive ideas, which created an intellectually stimulating environment for Thomas. This background influenced Malthus to approach societal issues with a blend of philosophical inquiry and empirical rigor. He received a classical education, attending Jesus College, Cambridge, where he excelled in mathematics and philosophy, graduating in 1788. His academic foundation, combined with his interest in economics and demography, prepared him to tackle pressing societal concerns.

Malthus' Motivations and Context

Malthus’ ideas were motivated by his concern for the well-being of society and his belief in empirical observation over speculative philosophy. He developed his theory in response to the optimistic views of thinkers like William Godwin and Marquis de Condorcet, who envisioned a society perfected through reason and equality. Malthus criticized these utopian ideals, arguing that they ignored the biological realities of population growth. He believed that unchecked population growth would undermine human progress by straining finite resources, leading to poverty and misery. His upbringing in a household influenced by the works of Jean-Jacques Rousseau and other Enlightenment thinkers provided him with a foundation in philosophical inquiry, yet his empirical approach marked a departure from their more idealistic views.

Core Ideas of Malthus' Population Theory

Malthus' theory is grounded in the principle that while the population grows geometrically, resource production increases arithmetically. This imbalance creates what he called a "Malthusian trap," where periods of population growth lead to resource scarcity, resulting in cycles of poverty and recovery. He identified three primary checks on population growth:

1. Vice: Social behaviors such as war or exploitation that directly or indirectly reduce population.
2. Misery: Natural calamities like famine and disease that limit population.
3. Moral restraint: Deliberate actions by individuals to delay marriage and reproduction.

Malthus' views on moral restraint were innovative, suggesting that societal progress depended on individual responsibility and ethical behavior.

Critiques and Counter Arguments

Malthus' ideas have been met with criticism from various perspectives. Karl Marx, for example, rejected Malthus' emphasis on population pressure as the root cause of poverty. Marx argued that poverty and inequality stem from systemic issues within capitalism, not from overpopulation. He believed that addressing economic structures and redistributing resources would eliminate poverty. This critique highlighted the sociopolitical dimensions of resource scarcity that Malthus largely overlooked.

Similarly, neoclassical economists challenged Malthus' pessimism by focusing on human ingenuity and market mechanisms. They argued that technological advancements and economic incentives could overcome resource limitations. For example, innovations in agriculture and energy production have demonstrated that production can keep pace with or even exceed population growth, mitigating some of the dire predictions made by Malthus.

Relevance to Global Warming and Environmental Challenges

Malthus' theory has enduring relevance, particularly in the context of modern environmental challenges like global warming. The parallels between his warnings about resource scarcity and today's climate crisis are striking. Population growth and increased consumption place immense pressure on natural resources, contributing to deforestation, greenhouse gas emissions, and ecosystem degradation. These factors exacerbate global warming, creating a feedback loop of environmental harm.

For instance, the demand for energy in rapidly growing populations often leads to increased reliance on fossil fuels, the primary driver of global warming. Similarly, the conversion of forests

to agricultural or urban land to accommodate population growth releases significant carbon dioxide into the atmosphere. Malthus' emphasis on the consequences of overpopulation underscores the urgency of addressing these challenges.

Integration of Malthus' Ideas into Thesis Development

This thesis explores the effectiveness of electric vehicles (EVs) in combating global warming, a contemporary manifestation of the resource constraints described by Malthus. By connecting Malthus' theory to modern environmental challenges, this study identifies overpopulation-driven resource consumption as a primary cause of environmental degradation. Building on Malthus' ideas, the thesis examines how technological solutions, such as EVs, can help alleviate pressure on resources. However, it also acknowledges the limitations of such technological solutions, reflecting criticisms from neoclassical economists who question the role of innovation in solving issues of scarcity.

Malthus' framework offers a valuable lens for analyzing the complex interplay between population dynamics, resource use, and environmental impact. By incorporating his insights, this thesis seeks to develop a comprehensive strategy for mitigating global warming—one that balances technological innovation with sustainable approaches to population and resource management.

The literature on Malthus provides critical perspectives on the relationship between population growth and resource constraints. His theory serves as a foundational framework for understanding the environmental challenges associated with global warming. Meanwhile, critiques from Marxist and neoclassical economists provide a more nuanced view, emphasizing the need for both systemic reform and technological innovation. By synthesizing these perspectives, this thesis contributes to the broader discourse on sustainability, offering solutions that address both the symptoms and root causes of global warming.

3. METHOD

This section outlines the methodology employed to address the research question: What is the most effective solution to global warming, based on electric vehicles, and how can it be implemented? The methodology includes a detailed explanation of the research type, data collection methods, data analysis approach, and ethical considerations, all of which were systematically designed to ensure the validity and reliability of findings.

This thesis employs a qualitative research design, selected to explore in-depth perspectives

and gather insights into global warming solutions, specifically focusing on electric vehicles (EVs). Qualitative data emphasizes non-numerical information such as personal experiences, societal trends, and expert opinions, making it suitable for the exploratory nature of this research. Data collection methods included surveys, case studies, and expert interviews. These methods enabled the integration of diverse viewpoints and validated information from credible sources.

The case study was used to systematically collect and interpret data from credible publications and organizations, including the US Environmental Protection Agency (EPA), CNBC, United Nations, BBC, and the Energy Information Administration (EIA). Data types ranged from textual reports to visual aids like charts and graphs. This method was crucial for validating survey opinions by providing reliable context and supplementary data. For instance, charts comparing EV and gasoline vehicle emissions were instrumental in corroborating claims about EV efficiency.

Surveys were conducted as a primary data collection tool. Designed as online questionnaires, the surveys targeted students from grades 7 and above at Cendekia Harapan School and other individuals to ensure diversity. The questions focused on public perceptions of EV effectiveness in reducing global warming, energy efficiency, and carbon footprint compared with traditional vehicles.

The sampling technique used was cluster sampling, chosen to focus on specific population subsets that could provide detailed responses. The survey period began on November 22, 2024, and initially aimed for 50 responses. Due to lower-than-expected participation, the period was extended until November 25, 2024, to meet the target.

To complement survey data, expert interviews were conducted with individuals knowledgeable about environmental science and technology, including teachers and industry professionals. Questions were designed to extract expert insights into the feasibility, efficiency, and environmental impact of EVs. Interviews were scheduled flexibly to accommodate the availability of experts. Sessions were recorded with consent and transcribed for analysis, ensuring a comprehensive and organized data set.

To ensure the reliability and validity of findings, this thesis employed data triangulation, a rigorous method of cross-verifying information from multiple sources. Triangulation compared insights from surveys, expert interviews, and case studies, ensuring consistency and accuracy. For example, claims made by survey respondents were verified against data from EPA reports and expert opinions to eliminate potential biases or inaccuracies. The triangulation process involved the

following steps:

1. Data Categorization

Grouping data into thematic categories, such as energy efficiency and carbon emissions. 2. Cross-referencing

Comparing data across surveys, interviews, and secondary sources to identify common patterns and discrepancies.

3. Validation

Testing the consistency of findings against authoritative sources like government reports and academic journals.

4. Synthesis

Integrating validated data to form coherent conclusions that directly address the research question. This structured approach ensured that conclusions were grounded in credible evidence and supported by diverse perspectives.

Ethical considerations were integral to this research to ensure integrity, transparency, and respect for participants and sources. All survey respondents and expert interviewees were informed about the purpose of the research, the methods used, and how their data would be utilized. Consent was obtained before participation. Participants' identities and responses were anonymized to protect their privacy. Data was securely stored and accessed only by the researcher. Participation in surveys and interviews was entirely voluntary, with participants free to withdraw at any time without consequences. Secondary data sources were carefully cited, ensuring that all referenced materials were appropriately credited and aligned with academic integrity standards. Efforts were made to frame survey and interview questions neutrally, reducing the risk of leading responses and ensuring that findings reflected genuine opinions and experiences.

4. RESULT AND DISCUSSION

Result

This section of the thesis will present the findings from research conducted to evaluate the role of electric vehicles (EVs) in mitigating the effects of global warming. It will identify the limitations of these EVs and promote strategies for EV adoption. By comparing Bali, an island in Indonesia, with a similarly sized country that has a more developed EV market, this thesis aims to highlight key factors influencing EV adoption and provide insights on enhancing EV adoption in

Indonesia. Based on the findings, this thesis will contribute to the development of a theoretical framework based on the best international practices to mitigate the effects of global warming.

Survey

The survey results indicate that only a small number of people own electric vehicles or hybrids, specifically, only 13.6% of the respondents own an electric vehicle and 4.5 % own a hybrid vehicle. The main reasons for not owning one include a lack of charging infrastructure, concerns about range, and high upfront costs. Some respondents noted that in Bali, where the survey was conducted, there are no charging facilities available. Additionally, others mentioned that gas-powered cars meet their needs, making electric vehicles less appealing due to their limited range and accessibility. Therefore, many see no need to purchase an electric vehicle. Among the respondents who own an electric vehicle, some mentioned that they purchased one because of long-term cost savings. One individual admitted that there was no specific reason for their purchase, it is possible that this respondent only purchased it because of other reasons aside from practicality. The majority of people expressed their interest and considered purchasing an electric vehicle in the future. A certain individual simply expressed interest in electric vehicles for their appearance.

All of these reasons align with previous studies. These studies show that electric vehicle adoption faces several challenges, especially in developing nations or nations with a developing electric vehicle market. High costs, limited range, and insufficient charging infrastructure are key barriers (M. Riezennman, 2020). These results also relate with the Malthusian theory of population, consumers demand a lot from electric vehicles for a low price yet our current technology is unable to deliver on these expectations. Based on the survey results, people would be more willing to purchase an electric vehicle if they had a longer range, faster recharge times, more charging infrastructure, or another benefit that would make them appear more appealing than gas-powered vehicles. To fulfill these demands, many changes must be made to the current electric vehicles which will be further discussed in later sections.

Case Study

The global movement toward sustainable transportation has intensified the urgency for the adoption of electric vehicles (EVs). Countries worldwide are increasingly prioritizing the reduction of greenhouse gas emissions and addressing climate change, thereby positioning EVs as an essential component of this pivotal transition. Within Southeast Asia, Singapore emerges prominently with the highest rate of EV adoption, comprising an impressive 19% of all-electric vehicles sold in the

region. The city-state has set an ambitious goal for electric vehicles to account for 80% of all vehicles on its roads by 2024. In contrast, Indonesia aims for a more modest target of 25% EV representation by the same year (Vanessa P. G., 2024).

Singapore's notable rate of EV uptake can be attributed largely to its unique urban challenges, characterized by high levels of congestion and limited physical space (Y. Wong et al., 2010). These factors not only act as catalysts for the adoption of EVs but also aid in enhancing effective city management and urban order. Complementing this, the introduction of a carbon tax levied on major industries that emit over 25,000 tonnes of carbon dioxide annually serves as another crucial incentive for promoting the use of electric vehicles. However, this tax seems to prioritize driving economic growth rather than achieving substantial reductions in carbon emissions (Hamilton-Hart, 2021).

In Indonesia, the typical price range for the most common electric vehicles falls between Rp 215,000,000 to Rp 327,000,000 (approximately $14,000 to $20,000 at current exchange rates). Unlike Indonesia, where affordability is a significant barrier, many individuals in Singapore have the financial resources to invest in electric vehicles without substantial obstacles.

To foster greater EV adoption and combat the challenges posed by global warming, Indonesia could benefit from exploring several strategies successfully implemented in Singapore. One such strategy could involve efforts to elevate the GDP per capita. However, it's essential to acknowledge that drawing a direct comparison between a compact, highly urbanized nation like Singapore and the vast, diverse archipelago of Indonesia can be somewhat misleading. The multitude of islands in Indonesia introduces distinct governance challenges that complicate the execution of new policies and the integration of innovative products like EVs.

Surveys conducted in Indonesia reveal a host of factors that deter consumers from embracing electric vehicles. Gaining a comprehensive understanding of these concerns is vital for identifying potential improvements that could enhance the appeal and practicality of EVs in the market. A significant barrier revealed through the survey is the insufficient charging infrastructure, which presents a considerable obstacle to broader EV adoption. Indonesia’s electric vehicle market is still nascent, having begun its development around 2017. In Bali, east of Java, the concept of EVs is even newer, gaining traction only recently over the past 2 to 5 years. Given this recent introduction, the consumer base for electric vehicles remains in the developmental stage. As we approach late 2024 and early 2025, several automobile manufacturers have just begun to penetrate

the Bali market, while established companies are expanding their electric vehicle offerings significantly. Observations indicate that the market for electric and hybrid vehicles continues to expand, with many manufacturers focusing on budget-friendly models tailored to the unique needs of the Balinese population. Meanwhile, Singapore has been at the forefront of EV exploration since 2011, even launching locally designed and manufactured electric vehicles crafted specifically for its urban environment (Massier et al., 2018).

A study conducted by T. M. Sweda and Diego K. in 2015 examined the scarcity of charging infrastructure within the Chicagoland area. It revealed that various factors—such as demand, geographic considerations, and demographic patterns—greatly influence the strategic placement of charging stations. Encouragingly, Indonesia has plans to deploy charging stations across the archipelago, though the specifics of this deployment strategy remain unclear. By contrast, Singapore has adopted a systematic and thoughtful approach to the placement of its charging stations, striving to achieve a balance between thorough network coverage and minimizing inconvenience for drivers. Moreover, the behaviors of drivers and the distances of their trips further impact the overall effectiveness of these charging stations. Evidence suggests that strategically placing charging stations at existing gas stations and parking facilities is often more efficient than adhering to a traditional grid layout (Bi et al., 2017). The study also highlighted a pattern wherein battery electric vehicles (BEVs) tend to be purchased more frequently when gasoline prices are elevated. However, intentionally increasing gasoline prices as a strategy to promote electric vehicles could provoke dissatisfaction among consumers. Additionally, sales of more fuel-efficient vehicles generally see an uptick during periods of high gasoline prices.

Another significant concern raised by survey participants revolves around the battery life and range of electric vehicles. These factors are critical for enhancing the efficiency and attractiveness of electric vehicles. However, advancements in battery performance often come with increased costs. Typically, a high-quality battery correlates with higher production costs, which, in turn, can escalate the overall price of the vehicle. Additionally, various other factors contribute to the pricing of electric vehicles, including costs related to construction, transportation, and the process of disassembly. In terms of recycling and disassembly, hydrometallurgy has emerged as the most effective method for handling used battery materials.

To summarize, unlike Bali, the majority of Singapore's residents can afford EVs, Singapore has begun systematically setting up charging infrastructure, Singapore's EV market is more

developed and has a well-built foundation, and Singapore has set up a carbon tax to promote cleaner energy. Singapore's unique urban challenges may have contributed to the quality of management and planning present in the country, which in turn further promoted the adoption of EVs.

Interview

The research revealed significant consequences of global warming and identified electric vehicles (EVs) as a promising solution to mitigate its effects. Advances in EV technology are providing opportunities to reduce greenhouse gas emissions and dependency on fossil fuels, but the findings also highlighted critical challenges in EV adoption and the broader implications of battery technology on environmental sustainability.

EV technology has progressed significantly in recent years. Developments in charging infrastructure and battery performance have enhanced the practicality and appeal of EVs. For instance, advances in charging speeds and the expansion of charging networks are improving accessibility for users, while innovations in battery technology, such as the Tesla Model S battery with a range of approximately 646,000 km, demonstrate the potential for extended range and durability (EVBox, 2024). However, several challenges persist. Unlike gasoline-powered vehicles, which can be refueled in minutes, EVs require extended charging times, which can prove problematic in emergencies or for users with limited access to charging facilities. Furthermore, charging station availability is still significantly lower than that of gasoline stations, posing logistical hurdles for widespread adoption. This transition also faces resistance from oil companies, whose vested interests in the gasoline economy create economic and political obstacles, as the adoption of EVs threatens their primary revenue streams. The establishment of an extensive EV charging infrastructure requires substantial investment and planning, further complicating the transition process (EVBox, 2023).

The study also emphasized the dual impact of battery technology on environmental sustainability. Improper disposal of household alkaline batteries, as highlighted in prior research, poses serious environmental risks due to their heavy metal content (Xará et al., 2015). Similarly, end-of-life management for EV batteries requires meticulous planning to avoid environmental harm. Implementing effective systems for recycling and recovering valuable metals from used batteries offers the potential for significant environmental and economic benefits. Such initiatives could reduce waste, lower dependence on mining rare earth materials essential for EV batteries, and contribute to a circular economy that supports sustainable development (Yousefi et al., 2023).

To address these challenges, the research explored potential innovations and solutions. One suggestion was the implementation of exchangeable EV battery systems. However, this approach faces practical limitations due to the heavy weight and precise placement requirements of EV batteries, which are critical for vehicle balance and safety. For example, the Tesla Model S battery weighs approximately 544 kg, making it difficult to handle and install without advanced systems (EVBox, 2023). A more feasible alternative could involve the development of lightweight, partially exchangeable emergency battery modules. These modules could provide limited ranges, such as 10 to 12 km, offering a practical solution for emergencies and reducing the reliance on full recharging in critical situations.

While EVs alone cannot solve the issue of global warming, the research underscores their potential to play a significant role in mitigation efforts. To fully leverage this potential, a comprehensive strategy is necessary. Governments, industries, and environmental organizations must collaborate to address economic and political barriers, such as those posed by oil companies, and to promote policies that encourage EV adoption, the development of renewable energy sources, and the establishment of sustainable infrastructure. Public awareness campaigns can also play a crucial role in educating individuals about the benefits of EVs and the importance of responsible battery disposal. Furthermore, continued investment in research and development is critical for overcoming the limitations of current EV technology and battery management systems.

In conclusion, the findings highlight the importance of EVs as a key element in reducing the impacts of global warming. By addressing the associated challenges through technological innovation, responsible battery management, and strategic policy interventions, the global community can take a significant step toward a more sustainable future.

Discussion

The findings of this study contribute valuable insights into the adoption and effectiveness of electric vehicles (EVs), emphasizing their potential role in mitigating global warming. The interviews conducted indicate strong evidence supporting EVs as a viable solution for reducing carbon emissions. However, for widespread adoption, it is crucial to cultivate consumer demand organically rather than relying solely on government mandates. The interplay between various factors such as environmental concerns, policy interventions, and consumer awareness—plays a key role in shaping the acceptance of EVs in society.

The increasing demand for EVs can be examined through the lens of Thomas Malthus'

population theory, which suggests that resource consumption often outpaces production capacity. In the case of EVs, the demand for technological resources—such as advancements in battery efficiency, infrastructure, and raw materials—continues to grow, raising concerns about sustainability. While Malthusian theory highlights the limitations of resource availability, it does not fully encapsulate the role of technological innovation in addressing these challenges. Unlike finite resources such as food, technological advancements have the potential to enhance production efficiency, making EVs more accessible over time. This aligns with the economic growth model, which argues that as nations develop, they become better equipped to integrate advanced technologies, including EVs. Singapore serves as a prime example, where high GDP per capita and proactive government policies have significantly accelerated EV adoption. In contrast, Indonesia's geographical and economic disparities hinder similar progress.

While Malthusian theory offers a framework for understanding the growing demand for EVs, it does not fully account for the influence of technological breakthroughs. Unlike food shortages predicted by Malthus, resource constraints in EV adoption—such as battery production limitations—can be mitigated through innovation and improved recycling methods. Additionally, the economic growth model highlights the role of government policies in shaping technological integration. While Singapore's strategic policy interventions, including carbon taxes and charging infrastructure investments, have facilitated EV adoption, Indonesia's fragmented geography presents logistical challenges that slow down implementation. This suggests that while economic factors play a role, strategic planning and policy adaptation are equally crucial for EV market expansion.

Several underlying factors influence EV adoption in Bali and Indonesia at large. Indonesia’s heavy reliance on fossil fuels remains a significant barrier to EV growth. Despite government incentives, the lack of a renewable energy infrastructure means that EVs in Indonesia often rely on electricity generated from coal and oil, diminishing their environmental benefits. Moreover, consumer skepticism regarding EV efficiency and affordability further hinders adoption. The study highlights that while public interest in EVs is growing, practical concerns such as limited charging infrastructure and battery longevity deter potential buyers. Additionally, cultural preferences play a role—many Indonesian consumers prefer gasoline-powered vehicles due to their familiarity and perceived reliability.

The findings of this study align with existing research on barriers to EV adoption. Studies

from developed markets, such as the United States and Europe, emphasize the importance of charging infrastructure, government incentives, and consumer confidence in promoting EV adoption (Bi et al., 2017). However, unlike Indonesia, these markets benefit from well-established EV ecosystems and consistent policy support. Comparisons with Singapore further underscore the impact of government-led initiatives on EV uptake. Singapore's implementation of carbon taxes and extensive investment in public charging stations contrast with Indonesia's slower policy adaptation. These disparities suggest that while economic factors influence EV adoption, proactive policy measures can significantly enhance market growth.

This study aimed to evaluate the role of EVs in mitigating global warming and to identify barriers to their adoption in Bali and Indonesia. The findings confirm that while EVs can contribute to reducing carbon emissions, their effectiveness is constrained by economic, infrastructural, and policy-related challenges. Addressing these issues is crucial to making EVs aviable solution for Indonesia's environmental goals. The case study comparison further reinforces that successful EV adoption requires a combination of technological readiness, government incentives, and regulatory support.

The practical implications of these findings suggest several actionable strategies for increasing EV adoption in Indonesia:

a. Investment in Charging Infrastructure

Expanding and strategically placing charging stations, similar to Singapore's approach, would enhance EV convenience and accessibility.

b. Government Incentives and Policies

Implementing carbon taxes, offering tax credits, and subsidizing EV purchases could encourage more consumers to transition from gasoline-powered vehicles.

c. Public Awareness and Education

Many respondents showed interest in EVs but lacked knowledge about their benefits and practical applications. Awareness campaigns highlighting cost savings, environmental impact, and long-term benefits could increase adoption.

d. Integration with Renewable Energy

Ensuring that electricity used to charge EVs comes from renewable sources would maximize their sustainability benefits.

Despite its contributions, this study has several limitations. The survey sample may not fully

represent the entire Indonesian population, as it primarily reflects perspectives from Bali. Additionally, the study captures a snapshot of current attitudes and adoption rates but does not account for potential shifts in government policy or technological advancements over time. Furthermore, while the case study compares Indonesia and Singapore, further research could explore other nations with comparable economic conditions and geographical challenges.

To build on these findings, future research could explore several areas. Longitudinal studies on EV adoption could track changes in consumer attitudes and adoption rates over time, assessing the impact of policy changes and technological advancements. Comparative studies across Southeast Asia could examine how different regulatory approaches impact EV adoption in countries with similar economic and infrastructural constraints. Additionally, economic feasibility studies could analyze the cost-effectiveness of potential EV incentive programs and their long-term economic benefits. Research on alternative battery technologies, such as solid-state batteries and hydrogen fuel cells, could provide innovative solutions to address current EV limitations and improve their overall efficiency and sustainability.

The study underscores the potential of EVs in mitigating global warming while highlighting the barriers that must be addressed for widespread adoption. While Indonesia faces significant challenges, insights from Singapore and other developed markets suggest that a strategic combination of policy support, infrastructure investment, and public awareness campaigns can accelerate EV uptake. Moving forward, a steady and well-planned transition—rather than an abrupt shift will be essential to ensuring sustainable and effective EV integration. Although EVs alone cannot resolve the issue of global warming, they represent a critical step toward a cleaner and more energy-efficient future.

In conclusion, the most effective way to combat global warming at this point is the use of EVs. By developing electric vehicles, we also enhance battery longevity and improve manufacturing and recycling processes. Although EVs cannot solve global warming, they lead us toward a more ideal solution. An increased demand for EVs would drive technological research, making it wise to adopt them now. This transition must occur steadily; a rapid shift could lead to unwanted consequences. To gradually increase the demand for EVs, consumer awareness must be raised alongside government incentives and heightened environmental concerns. These efforts should be implemented thoughtfully and ethically, avoiding any unethical methods. The conceptual framework illustrating the relationship between EVs and global warming is shown in the diagram

below.

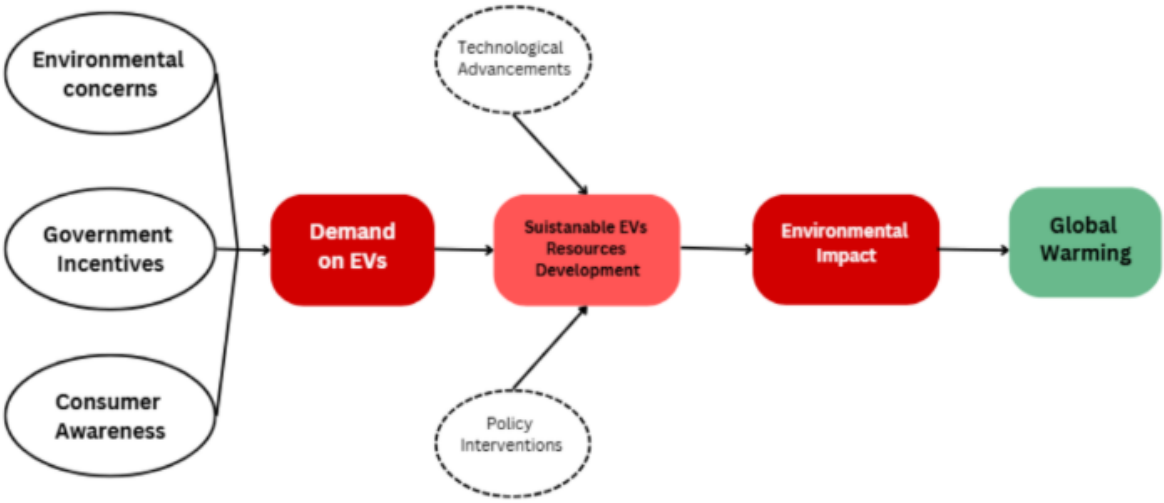

Figure 1. Conceptual Framework of EVs and Global Warming.

The diagram illustrates how Electric Vehicles (EVs) contribute to mitigating global warming by transforming the demand for sustainable transportation into positive environmental impact. Demand for EVs is primarily driven by three key factors: environmental concerns, government incentives, and consumer awareness. As more people recognize the environmental benefits of EVs and as governments implement policies to encourage their adoption (such as tax incentives and subsidies), the demand for EVs increases.

This growing demand leads to sustainable EV resource development, which is influenced by technological advancements and policy interventions. Technological advancements help improve battery efficiency, charging infrastructure, and the overall sustainability of EV production, while policy interventions ensure that regulations align with long-term environmental goals. As a result, the adoption of sustainable EVs reduces negative environmental impacts, such as carbon emissions from fossil fuel-powered vehicles. This reduction in environmental impact directly contributes to slowing down global warming by decreasing greenhouse gas emissions.

Malthus' theory argues that as demand increases, resources will inevitably become depleted, leading to shortages and crises. According to his perspective, if EV demand rises significantly, the resources required for their production (such as lithium, cobalt, and other rare earth materials) would eventually be exhausted, making sustainable EV development unsustainable in the long run.

However, this diagram challenges Malthus' perspective by showing that technological advancements and policy interventions play a crucial role in resource sustainability. As demand for EVs increases, humans innovate and find ways to expand resource availability—for example,

through battery recycling, alternative battery technologies (such as solid-state or sodium-ion batteries), and improvements in energy efficiency. This means that rather than simply depleting resources, higher demand accelerates technological progress, which in turn expands the resource base and makes sustainability achievable.

Thus, while Malthus' theory assumes that resources are static and finite, this model demonstrates that human innovation can offset resource scarcity by creating new solutions, ensuring that increased EV adoption remains a viable strategy for addressing global warming. Instead of a crisis due to resource depletion, innovation leads to a sustainable transition toward cleaner transportation.

5. CONCLUSION

This study has examined the role of electric vehicles (EVs) in mitigating global warming and the key challenges affecting their adoption in Indonesia, particularly in comparison to Singapore. The findings confirm that while EVs have significant potential to reduce carbon emissions, several economic, infrastructural, and policy-related barriers hinder widespread adoption. These include high initial costs, limited charging infrastructure, range anxiety, and consumer skepticism—challenges that align with existing literature on EV adoption in developing markets.

The discussion highlights that successful EV adoption requires a multi-faceted approach. Lessons from Singapore demonstrate that strong government policies, economic incentives, and well-developed infrastructure can significantly accelerate EV uptake. Similarly, technological advancements in battery efficiency, faster charging, and the integration of renewable energy sources are crucial in ensuring that EVs genuinely contribute to environmental sustainability.

From a theoretical perspective, the study relates EV adoption to Malthusian theory, suggesting that while demand for EVs is growing, technological advancements must keep pace with consumer expectations. However, unlike Malthus' predictions of absolute resource depletion, technological innovations—such as solid-state batteries and hydrogen fuel cells—could help overcome existing limitations. The economic growth model further supports the idea that as nations develop, they gain the capacity to integrate advanced, sustainable technologies like EVs.

While this research provides valuable insights, it is not without limitations. The study primarily reflects perspectives from Bali, and findings may not be fully generalizable across

Indonesia. Additionally, the analysis captures current adoption trends but does not account for future shifts in government policy, infrastructure development, or consumer behavior. Further research should adopt longitudinal methods to track EV adoption trends over time, conduct comparative analyses across Southeast Asia, and explore the long-term economic feasibility of EV subsidies and incentives.

In conclusion, the widespread adoption of EVs is a critical step toward a cleaner, more energy-efficient future, but it must be accompanied by strategic infrastructure development, policy support, and consumer awareness initiatives. A gradual and well-planned transition—rather than an abrupt shift—will ensure sustainable, long-term integration of EVs into Indonesia's transportation sector. While EVs alone cannot fully resolve global warming, they represent a significant advancement in sustainable mobility and environmental conservation.

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