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Changes in the Use of Fuel Oil Into Electyrical Energy for Vehicles

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Abstract
The global transportation sector faces critical challenges due to heavy dependence on fossil fuels, contributing significantly to greenhouse gas emissions and air pollution while creating economic vulnerabilities through volatile fuel prices and import dependencies. This study aims to comprehensively analyze the factors driving the transition from fuel oil to electric vehicles, evaluate the comparative advantages of electric vehicles over conventional vehicles, identify implementation challenges, and formulate innovative solutions to accelerate energy transition in the transportation sector. The research employs a qualitative approach using systematic literature review methodology, analyzing data from international energy organizations (IEA, IRENA), government policy documents, automotive industry reports, and academic journals to provide comprehensive evaluation of electric vehicle adoption trends, technological developments, and policy frameworks across different countries. Key findings reveal that electric vehicles achieve superior energy efficiency (>90%) compared to internal combustion engines (30-40%), offer significant long-term cost savings through reduced maintenance requirements and stable electricity pricing, and provide substantial environmental benefits through zero direct emissions. However, challenges include limited charging infrastructure, high initial purchase costs, and battery technology limitations in terms of storage capacity and charging time. With the supporting policies, this transition has the potential to provide long-term benefits, both for the environment and future energy security. The research implications suggest that successful electric vehicle adoption requires integrated approaches combining technological innovation, infrastructure development, and public awareness campaigns to create sustainable and efficient transportation systems for the future.

Keywords: Electric vehicles, sustainable energy, energy transition, power efficiency.

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INTRODUCTION

Climate change and the high dependence on fossil fuels remain major obstacles toward realizing an environmentally friendly transportation system (Johnsson et al., 2019). Public vehicles significantly contribute to greenhouse gas emissions, primarily due to their reliance on petroleum-based fuels (IESR, 2020). As a result, transitioning public transport fleets to electric vehicles (EVs) is increasingly embraced globally—including in Indonesia—as an effective mitigation strategy. EVs outperform conventional vehicles in terms of energy efficiency and emission reductions, and they offer promising synergies when paired with renewable energy sources (Chen, 2024; Zhao, 2023). However, the adoption of EVs faces several key challenges: Indonesia suffers from insufficient charging infrastructure, compounded by limited consumer awareness and financial constraints (Lazuardy et al., 2024). Additionally, electrification elevates electricity demand, which necessitates careful grid planning and expansion (Amilia et al., 2022). To succeed, this technological shift requires comprehensive and supportive government policies, such as Presidential Regulation No. 55 of 2019, which aims to accelerate electric mobility across road transport (ERIA, 2023). Taken together, these factors illustrate that while EVs hold immense promise, overcoming infrastructural, economic, and regulatory barriers is essential for a successful transition in Indonesia and beyond.

Transportation is one of the sectors with the largest energy consumption in the world. Most vehicles used today are still dependent on fuel oil (BBM) as the main source of energy. In Indonesia, the transportation sector contributed more than 40% of the total national fuel consumption, which mostly came from imports (Ministry of Energy and Mineral Resources, 2023). Dependence on fuel causes two main problems, namely the negative impact on the environment and national energy security.

Environmentally, oil-fueled vehicles contribute greatly to air pollution and global climate change. Greenhouse gas emissions (GHG) produced by conventional vehicles, such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxide (NOx), and fine particulates (PM2.5), have been proven to cause various health and environmental problems (World Health Organization, 2023). In big cities like Jakarta, air pollution from motorized vehicles is a major factor that causes respiratory diseases and decreased air quality.

In addition, petroleum resources are not renewable and continue to decline. With the increasing demand for global energy, fuel prices become unstable and tend to increase. This adds to the economic burden for countries that still rely on fuel imports.

As a solution to the problem, the use of electric vehicles began to be developed as a cleaner and more efficient alternative. Electric vehicles do not produce direct emissions and have higher energy efficiency than oil-fueled vehicles. Technological support, government policy, and increasing public awareness have encouraged the adoption of electric vehicles globally.

The urgency of transitioning from fossil fuel to electric vehicles has become increasingly critical due to several converging global factors. First, the transportation sector accounts for approximately 24% of global energy-related CO_2 emissions, making it a priority area for decarbonization efforts to meet Paris Agreement targets. Second, the rapid depletion of global petroleum reserves and increasing energy security concerns have highlighted the need for alternative energy sources in transportation. Third, air quality deterioration in major urban centers worldwide has reached crisis levels, with transportation-related emissions being a primary contributor to public health problems including respiratory diseases and cardiovascular complications.

Previous research has established substantial evidence supporting electric vehicle adoption across multiple dimensions. Studies by Chan and Chau (2021) demonstrated the technical feasibility and efficiency advantages of electric powertrains compared to internal combustion engines. Research by Li et al. (2020) analyzed the economic implications of electric vehicle adoption, revealing significant long-term cost savings despite higher initial investments. Environmental impact assessments by Thompson and Rodriguez (2022) confirmed substantial greenhouse gas emission reductions achievable through electric vehicle deployment. Policy analysis by Martinez et al. (2021) examined successful government incentive programs and their effectiveness in accelerating electric vehicle market penetration. Recent technological advancement studies by Kumar and Singh (2023) highlighted rapid improvements in battery technology and charging infrastructure development.

However, significant research gaps remain in current electric vehicle literature. Most existing studies focus on developed country contexts, with limited comprehensive analysis of electric vehicle adoption challenges and opportunities in developing countries like Indonesia. There is insufficient research examining the integrated relationship between technological advancement, policy frameworks, and social acceptance factors in electric vehicle transition. Furthermore, limited studies have systematically evaluated the comparative analysis of different electric vehicle technologies and their suitability for various transportation applications in emerging markets.

The novelty of this research lies in its comprehensive approach to analyzing electric vehicle transition specifically within the Indonesian context, integrating technological,

economic, environmental, and policy perspectives to provide holistic understanding of factors influencing electric vehicle adoption in developing countries. This study fills the research gap by offering systematic evaluation of electric vehicle implementation challenges and opportunities tailored to Indonesian transportation sector characteristics and infrastructure conditions.

The primary objective of this research is to explore the factors that encourage the transition from fuel oil to electricity in the transportation sector, identify the superiority of electric vehicles over conventional vehicles, examine challenges in implementation, and formulate innovative solutions to accelerate energy transitions. Secondary objectives include analyzing the environmental and economic benefits of electric vehicle adoption, evaluating current policy frameworks and their effectiveness, assessing technological readiness and infrastructure requirements, and developing strategic recommendations for sustainable transportation system development. The research benefits include providing evidence-based guidance for policymakers developing electric vehicle adoption strategies, supporting automotive industry stakeholders in understanding market opportunities and challenges, contributing to environmental sustainability initiatives through transportation sector decarbonization, and advancing academic knowledge in sustainable transportation systems. The implications of this study extend to supporting Indonesia's commitment to reducing greenhouse gas emissions, enhancing national energy security through reduced fuel imports, and contributing to improved public health through reduced air pollution in urban areas.

This study aims to explore the factors that encourage the transition from BBM to electricity, identify the superiority of electric vehicles, examine challenges in its implementation, and formulate innovative solutions to accelerate energy transitions in the transportation sector.

Electric vehicles have various advantages compared to fossil-fueled vehicles, including:

1. Higher energy efficiency: Electric motors are able to change energy with efficiency reaching 90%, far higher than the internal combustion engine which only has an efficiency of around 30%.
2. Reduction of carbon emissions: Electric vehicles do not produce emissions directly, so that it can help reduce air pollution.
3. Support for renewable energy: Filling in electric vehicles can utilize energy sources such as solar power and wind, which further increases environmental sustainability

RESEARCH METHOD

This method is used to collect, analyze, and synthesize various sources of literature related to electric vehicles, energy transitions, and challenges and opportunities. This study uses a qualitative approach with literature study methods that focus on descriptive analysis of various sources related to changes in the use of fuel oil into electrical energy for vehicles. The qualitative approach was chosen because this research was not oriented towards numbering or statistics measurements, but rather in an in-depth understanding of the factors that affect energy transitions in the transportation sector and their impact on the environment, economy, and public policy.

RESULTH AND DISCUSSION

The results of this study indicate that the transition of oil -fueled vehicles to electric vehicles is increasing globally, including in Indonesia. One of the main factors that encourage this shift is the increase in awareness of the environmental impact caused by greenhouse gas emissions from conventional vehicles. According to the International Energy Agency (IEA) report, the transportation sector is one of the biggest contributors to carbon dioxide (Co_2), which contributes to global warming and air pollution in urban areas (IEA, 2023). Therefore,

electric vehicles are seen as an alternative that is more environmentally friendly because it does not produce emissions during its use.

In addition, this study also found that electric vehicles have a much higher energy efficiency than internal combustion engined vehicles. Based on data from U.S. Department of Energy, electric vehicles can achieve more than 90% efficiency, while oil-fueled vehicles only range from 30-40% (U.S. Department of Energy, 2023) . This indicates that electric vehicles are able to utilize energy more optimally, so that it is more efficient in the consumption of power and operational costs in the long run.

From the economic aspect, although the price of electric vehicles is currently still more expensive than oil -fueled vehicles, the maintenance costs are much lower. This is caused by a simpler electrical vehicle structure, with fewer moving mechanical components, thereby reducing the need for routine maintenance such as oil changes and engine service. In addition, the cost of charging electricity is also more stable compared to the price of fuel oil that often experiences fluctuations due to dependence on global supply. The government in various countries, including Indonesia, has provided various forms of incentives to increase the adoption of electric vehicles, such as tax exemption, purchase subsidies, and reduced electricity tariffs for charging at the Public Electric Vehicle Filling Station (SPKLU) (Indonesian Government, 2023).

However, this research also found several challenges that are still obstacles in the implementation of electric vehicles. One of them is the limited charging infrastructure, especially outside of big cities, which are still the main concerns for prospective electric vehicle users. In addition, the battery technology used today still has limitations in terms of energy storage capacity and relatively long charging time. Although there are research on solid-state batteries, which are claimed to be more efficient and have a longer use of life, this technology is still in the development stage and has not been widely applied (International Renewable Energy Agency, 2023) .

Overall, the results of this study indicate that electric vehicles are a promising solution to reduce dependence on fuel oil and suppress greenhouse gas emissions. However, so that this transition is more optimal, it is necessary to support policy that is stronger than the government and technological innovation in the automotive industry, especially in the development of charging infrastructure and increasing battery efficiency. With the right strategy, electric vehicles can be an important part of realizing a more sustainable transportation system in the future.

Discussion

Environmental Impact and Air Quality Improvement

Air pollution will eventually increase over time and this will result in increasingly bad air quality for survival, the cause of decreased air quality is caused by smoke from motorized vehicles such as cars and motorcycles that use fuel from petroleum (fossils). This happens because there are already many residents in Indonesia and even in the world that have motorized vehicles that use BBM. This results in increased air pollution due to vehicles that are not environmentally friendly. Therefore the local government and even the world seeks to minimize air pollution that occurs by creating a new innovation in the world of transportation. Then the creation of an environmentally friendly vehicle, which uses electrical energy as the main fuel to replace fuel oil.

Energy Efficiency and Technological Advantages

Changes in the use of fuel oil towards an electric system reflect new awareness of cleaner and more efficient energy needs. Electric vehicles offer a simpler and more efficient work system in utilizing energy. This means that most of the energy used is completely converted into power, in contrast to conventional vehicles that dispose of energy in the form

of heat. The superior efficiency of electric vehicles stems from the fundamental differences in energy conversion mechanisms. While internal combustion engines lose significant energy through heat dissipation, friction, and incomplete combustion, electric motors directly convert electrical energy into mechanical motion with minimal energy loss. This efficiency advantage translates into reduced overall energy consumption and lower operational costs over the vehicle's lifetime.

Economic Considerations and Cost Analysis

The cost of ownership of electric vehicles in the long run is also lower. This is related to the lack of machine components that require maintenance. There is no need to change oil or do regular service that is complicated such as in gasoline vehicles or diesel. Plus, the price of electricity as an energy source tends to be more stable and can be predicted compared to the price of fluctuating fuel oil due to global influence. This is one of the reasons why consumers begin to glance at electric vehicles as an alternative to more efficient transportation.

Implementation Challenges and Barriers

However, the adoption of electric vehicles has not been running without obstacles. One of the main obstacles is the limited charging network, especially in unprofiled areas. User fear will run out of power when driving far or in areas with minimal infrastructure becomes a significant adoption inhibiting factor. In addition, the price of electric vehicles that are still relatively high is also a challenge. The price is mostly due to the high cost of battery components that still rely on raw materials such as lithium and cobalt that are expensive and difficult to obtain.

Technological Innovation and Future Opportunities

In the midst of these challenges, there are also great opportunities for the development of alternative technology, such as sodium-based batteries or solid-state batteries that are safer, lighter, and durable. If this innovation is successfully implemented en masse, the price of electric vehicles can be reduced and becomes more affordable for the wider community. Emerging battery technologies, including lithium iron phosphate (LiFePO4), solid-state electrolytes, and alternative chemistry solutions, promise to address current limitations in energy density, charging speed, and cost. Advanced manufacturing techniques and economies of scale are expected to significantly reduce battery costs, making electric vehicles more economically competitive with conventional vehicles.

Policy Framework and Government Support

From a policy point of view, government involvement is very important. Supporting regulations and providing incentives can accelerate the process of energy transition in the transportation sector. Presidential Regulation Number 55 of 2019 in Indonesia is one example of the government's concrete steps in supporting the electric vehicle ecosystem. Comprehensive policy frameworks require coordination across multiple sectors including energy, transportation, urban planning, and industrial development. Successful electric vehicle adoption programs typically include purchase incentives, charging infrastructure development, emissions standards, and research and development support for domestic manufacturing capabilities. If all of these elements run in line—the support of technology, economy, and policies—then electric vehicles can really be the backbone of sustainable transportation in the future.

CONCLUSION

Based on the comprehensive research and analysis conducted, this study concludes that the transition from oil-fueled vehicles to electric vehicles represents a strategic and necessary step toward reducing fossil energy dependence and mitigating negative environmental impacts. Electric vehicles demonstrate superior energy efficiency compared to conventional vehicles, achieving over 90% energy conversion efficiency versus 30-40% for internal combustion

engines, resulting in significantly reduced overall energy consumption and operational costs. The economic advantages of electric vehicles extend beyond efficiency gains to include lower maintenance requirements due to simpler mechanical structures, stable electricity pricing compared to volatile fuel costs, and various government incentives including tax exemptions and purchase subsidies that enhance affordability.

However, the transition to electric vehicles continues to face significant challenges that require systematic solutions. Infrastructure limitations, particularly the uneven distribution of charging stations outside major urban centers, remain a primary concern for potential users experiencing range anxiety. The relatively high initial purchase prices of electric vehicles, primarily driven by expensive battery components requiring rare materials like lithium and cobalt, present economic barriers to widespread adoption. Battery technology limitations regarding storage capacity, charging time, and lifespan continue to impact user acceptance and operational efficiency.

To address these challenges and accelerate electric vehicle adoption, several strategic recommendations emerge from this research. First, continued technological innovation is essential, particularly in developing more efficient and affordable battery technologies such as solid-state batteries, sodium-based alternatives, and advanced manufacturing processes that can reduce costs while improving performance. Second, comprehensive infrastructure development is required, including strategic expansion of public charging networks (SPKLU) to ensure adequate coverage in both urban and rural areas, supported by grid modernization to handle increased electricity demand. Third, integrated policy support combining government incentives, private sector partnerships, and regulatory frameworks that encourage clean transportation adoption while supporting domestic automotive industry development.

The synergy between government policy, automotive industry innovation, and community acceptance is crucial for successful electric vehicle transition. Future research should focus on developing localized solutions adapted to Indonesian geographical and economic conditions, investigating the integration of renewable energy sources with electric vehicle charging infrastructure, and analyzing the long-term impacts of large-scale electric vehicle adoption on energy systems and urban planning. With coordinated efforts across technological, economic, and policy dimensions, electric vehicles can become the foundation of sustainable, environmentally friendly, and energy-efficient transportation systems that contribute meaningfully to climate change mitigation and national energy security objectives.

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