E ISSN 2407-635x | P ISSN 2356-5519
https://journal.itltrisakti.ac.id/index.php/jmtbtl

Reducing Carbon Emissions in The Indonesian Logistics Industry: A Delphi Study

Jeremy Ephraim Simarmata[a], Jean Sebastian Simarmata[b], Juliater Simarmata[c], Reni Dian Octaviani[d]

[a]Faculty of Management and Business, Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia

[b]Faculty of Management and Business, Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia

[c]Faculty of Management and Business, Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia

[d]Faculty of Management and Business, Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia

Corresponding author: jean.simarmata75@gmail.com

Abstract: The logistics and transport industry significantly contributes to global carbon emissions, underscoring the urgent need for technological and regulatory interventions to mitigate its environmental impact, as outlined in the Paris Agreement. This study investigates strategies for reducing carbon emissions within Indonesia's logistics sector using the Delphi method. Key areas explored include vehicle age regulation, incentives for electric vehicle (EV) adoption, and the enhancement of biofuel usage. By gathering expert insights from industry leaders, regulators, and academics, the research addresses crucial issues and identifies effective solutions. The findings reveal a consensus on the pivotal role of EVs in mitigating carbon emissions and emphasize the necessity of supportive policies and infrastructure to enable this transition. The study also evaluates the effectiveness of low emission zones and the potential of biofuels as alternative energy sources. Results indicate that while the adoption of EVs and biofuels offers significant benefits, challenges such as high costs and insufficient infrastructure remain substantial barriers. Furthermore, the research highlights the need for robust regulatory frameworks and financial incentives to foster the adoption of cleaner technologies. This study enhances understanding of carbon reduction strategies in the logistics industry and offers actionable recommendations for policymakers and business leaders to expedite the transition to a more sustainable and low-carbon logistics sector in Indonesia.

Keywords: Paris Agreement, Vehicle Age, EV underutilization, Low emission zones, renewable fuel standards.

*Correspoding email: jean.simarmata75@gmail.com

1. Introduction

The logistics and transport industry makes up more than one-third of the world's total carbon emissions (*ISO - Towards a Net-Zero Logistics Sector*, 2023). Due to its crucial nature, it is vital that the industry is propelled towards decreased carbon emissions through technology as well as governmental policies and incentives. A number of other essential industries such

as energy and utilities have proven it is feasible to incorporate other forms of energy to reduce their environmental impact (Fang et al., 2023). The logistics sector is one of the sectors expected to make progress in order to contribute to the fulfillment of the goals set by the Paris Agreement. The Paris Agreement outlines that global warming must be limited to 1.5 degrees Celsius above pre-industrial levels, along with other guidelines such as increased transparency and accountability. Indonesia, a signee of the agreement has made promising steps in the right direction. The country's plan of action lists down several decisive policies, although it is yet to be put into full throttle.

The logistics industry is the heart of trade and commerce. It facilitates the movement of goods from one part of the world to another. It is the industry that quite literally never sleeps, even during the bleak pandemic, logisticians around the world facilitated the movement of vital goods such as food, and medicine. The global logistics market size is $10.41T (Placek, 2023). Having such a big market size answers why logistics is sometimes considered the cost center for many business operations. This translates to a country's dependence on a good and well-run logistics process to ensure global competitiveness. Although, with the dawn of technology, these problems are slowly but surely being alleviated.

The global shift in prioritizing sustainability activated a somewhat vague deadline for the logistics industry to accomplish. Fortunately, due to the large scope of operations that is involved in logistics, it allows for a wider approach to the problem of unoptimized emissions. Many things in the logistics industry remain unchanged despite the rapid innovation in other essential sectors. This paper takes a multi-faceted approach that intends to explore issues within the logistics industry that can bring collaboration between multiple industries, regulators, as well as practitioners.

A vehicle's age is an important indicator of not only its carbon emissions, but its safety, and reliability (Zachariadis et al., 2001). Financial implications constitute most of the concerns when it comes to regulating a transport vehicle's road worthiness based on its age, along with other variables. Industry players may benefit from a fractional decrease on insurance premiums, but it comes at a hefty cost of regular breakdowns. Therefore, it is imperative to regulate the age of vehicles used commercially such as heavy-duty trucks.

One of the main policies underlined in Indonesia's transparency report in accordance with the Paris Agreement's requirements is the effort to transition significantly from traditional combustion engines to electric vehicles. Although progress has been made, it has proven to be minute in comparison to the results expected (Lisa Wijayani et al., 2022). Commercial use of these vehicles in land transport has seen even less implementation. It is important to note however that there are multiple factors that are involved including but not limited to the nascent technology, its reliability, and most importantly its astronomic costs (Shirvani et al., 2024).

Low emission zones have recently been widely effectuated, especially in the European Union, with many more to come in countries like Spain looking to more than 10x their current low emission zones. Low emission zone implementation has proven to constraint pollution in cities, especially effective and noticeable in cities with extreme cases of pollution (Bernardo

et al., 2021). Although it comes with the assumption that it will also help curb congestion, research proves that it unfortunately does not have any strong substantiation.

In the subject of vehicles, their emissions can roughly be estimated by their fuel efficiency with the type of fuel being a big determinant in the final emission. Biofuel is an interesting and promising answer to reducing emissions across the board. It comes with all the typical setbacks including higher costs. However, as the bio-fuel production technology and capacity increase with time, its cost will begin to level and its widespread use can significantly decrease emissions (Kumar et al., 2022). A helping hand from the authorities in monetary or other forms may greatly accelerate the timeline of bio-fuel's development.

Given the urgent need to find and implement innovative solutions within the logistics and transport industry, this paper raises and investigates the following research questions:

1. What policy/regulation regarding a commercial vehicle's age can reduce the carbon emissions in Indonesia?
2. What is the right strategy to incentivize the use of EVs for logistics industry purposes in order to facilitate a large-scale transition?
3. Will Indonesia's biofuel capacity and regulation be enough to facilitate moving away from fossil fuels?

2. Literature Review

2.1 Emission Gas and Low Emissions Zones

In the research of Ferdnian (2016), there are four main emissions produced by vehicles: Hydrocarbons (HC), Carbon Monoxide (CO), Carbon Dioxide (CO2), and Lead (Pb). Various types of emissions are produced by motor vehicles, but Carbon Monoxide (CO) is one of the dominant, with a contribution of 75.4% of total emissions (Hodijah & Amin, 2014). Hadiharja in Damara, Wardhana and Sutrisno research (2017) said that the largest source of CO gas pollution based on research in industrialized countries comes from fossil fuels in transportation propulsion engines. Gas emissions cause many impacts on health and various environmental impacts. Therefore, reducing emissions is urgently needed, especially in urban areas, especially in the city of Jakarta, Indonesia.

In the research of Margaryan (2021) Air quality in big cities has seen a decline partly due to the increase of mobility via motor vehicles, a big part of this is commercial vehicles. Low Emissions zones are one of the regulatory instruments enacted to reduce emissions. LEZ is already in force in European countries. The Research from Bernando, Fageda, and Flores-Fillol (2021) works with theoretical models in order to find a scenario in which low emission zones provide the most amount of positive impact. It analyses congestion and incorporates pollution into the calculation as well. Their research concludes that LEZs are in fact effective in curbing pollution. On the other hand, it is not as effective in lowering congestion. In conclusion, LEZs are most effective when used in a highly polluted, and large area city.

Indonesia, especially Jakarta, is a perfect place where the results may be amplified. In a dense city with a large number of motor vehicles, both personal and commercial, the impact of a low emission zone would be considerably positive.

2.2 Biofuel and the Transition from fossil fuel

One of the largest emitters of greenhouse gases is the transportation sector. The operation of transportation is inextricably linked to the use of fuel, which is currently dominated by conventional fossil fuels. However, fossil fuels have significant environmental impacts, contributing to air pollution, greenhouse gas emissions, and climate change (Gupta et al., 2022). Therefore, the adoption of alternative fuels is urgently needed to mitigate these adverse effects.

Bioenergy is one of the alternative fuels that can be implemented in transportation, offering a viable option to reduce emissions in the sector (Reid et al., 2020). However, the transition from fossil fuels to bioenergy is complex and requires concerted efforts from policymakers. To increase the usage of bioenergy, policymakers must take decisive actions focused on ensuring that bioenergy contributes to climate mitigation in the short term while reducing the risks of economically and environmentally harmful path dependency in the long term (Reid et al., 2020). This involves creating supportive regulatory frameworks, incentivizing research and development in bioenergy technologies, and promoting sustainable bioenergy production practices to ensure a smooth and effective transition.

2.3 Current State of Carbon Emission in Indonesian Logistics

Based on the Climate Transparency Report (Climate Transparency, 2022), the transportation sector accounted for nearly 24.9% of total carbon emissions in Indonesia in 2022. The report reveals that the transportation sector in Indonesia remains heavily reliant on energy from oil as the primary fuel source, with 86% of total energy consumption coming from oil, while the remaining 14% is derived from biofuels. This high dependency on oil indicates the urgent need for a faster transition to cleaner and renewable energy sources to reduce carbon emissions and mitigate negative environmental impacts.

The latest report from the Jakarta Environment Agency reveals that the land transportation sector is a major contributor to air pollution in the Jakarta area, accounting for around 75% of total pollutant emissions (Media Indonesia, 2023). This data shows how significant the impact of motor vehicles, such as cars, buses, and motorcycles, is on air quality in the capital. Therefore, strategic measures and appropriate policies are needed to reduce emissions from the transportation sector to improve air quality and public health in Jakarta.

2.4 Policy and regulatory frameworks

The policy on battery-based electric motorized vehicles is an integral part of Indonesia's national energy policy, which is governed by a clear legal framework to promote the use of renewable energy and energy conservation. The government pays significant

attention to the transition to renewable energy through specific provisions that offer various conveniences, including financial incentives such as tax reductions and subsidies, as well as administrative ease in the form of simplified and expedited licensing processes. These measures aim to accelerate the adoption of electric motorized vehicles, reduce carbon emissions, and decrease dependency on fossil fuels, reflecting Indonesia's commitment to a cleaner and more sustainable future.

Law Number 30 Year 2007 concerning Energy is a law that encompasses all forms of energy supply and utilization, including renewable energy. From Law Number 30 Year 2007 concerning Energy, two government regulations related to energy use have been issued: Government Regulation No. 74/2014 concerning National Energy Policy and Government Regulation No. 70/2009 concerning Energy Conservation. Subsequently, another derivative regulation specifically addressing BEVs was introduced through Presidential Regulation No. 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation (the BEV Regulation). This regulation was later amended by Presidential Regulation No. 74 of 2023, which addresses changes to Presidential Regulation No. 55 of 2019 on the acceleration of the battery electric vehicle program for road transportation. The BEV Regulation embodies Indonesia’s commitment to reducing greenhouse gas emissions, necessitating the acceleration of the BEV program for road transportation. Research of Yuniza also said that Indonesia already has legal frameworks for developing BEV, however there are problems in incentive policies, two of them are: Lack of control over conventional Vehicles and There is still a need for various technical regulations or regional Government regulations to support the presidential regulation on BEV (Yuniza et al., 2021).

2.5 Technological Innovation and Solution

An Electric Vehicle (EV) is a vehicle that uses one or more electric motors for its propulsion, in contrast to conventional vehicles that use an internal combustion engine. EVs can be driven by energy stored in batteries or other energy storage systems. According to EU Directives (European Union's, 2014), an electric vehicle is defined as a motor vehicle equipped with a powertrain containing at least one non-peripheral electric machine as an energy converter with an electric rechargeable energy storage system that can be recharged externally.

There is widespread acceptance that transitioning to private electric vehicles is a step in the right direction. However, a significant portion of emissions from the logistics and transport industry come from the commercial sector. The research of Wilczarcska, Prusiewicz, Kulis, and Martinez (2024) analyzes the feasibility of using electric vehicles for short-distance deliveries within the logistics field. The study’s context aligns well with some of Jakarta's characteristics, suggesting the potential use of electric vehicles for middle and last-mile delivery services in urban logistics operations. By integrating electric vehicles into logistics networks, companies can reduce their

carbon footprint, enhance sustainability, and improve air quality in densely populated areas. This transition not only supports environmental goals but also aligns with the growing demand for greener logistics solutions in the industry.

Furthermore, transitioning to electric vehicles offers significant environmental and economic benefits for Indonesia, like other countries. These benefits include reducing environmental damage and providing an economic boost through increased nickel production and growth in the automotive industry. Road transport is a major source of air pollution, contributed by both private mobility and commercial logistics. Mobility is essential and cannot be eliminated; however, the type of vehicles used to transport people and goods in cities can significantly impact environmental health. Shahboz and Koestoer (2023) say that older motor vehicles cause a disproportionate amount of environmental damage, reinforcing the need for adopting newer, cleaner technologies like electric vehicles.

2.6 Business strategies for carbon reduction

In the carbon reduction plan stipulated in the Paris Agreement, the transportation sector, particularly land transportation, holds a significant responsibility. Logistics companies, as part of this sector, are accountable for reducing the carbon footprint of their operations. An important area that demands careful management is how businesses handle their fuel consumption to minimize carbon dioxide (CO2) emissions resulting from their transportation and logistics operations (Mubarak & Rahman, 2020). Research by Bouman (2017) indicates that the use of biofuels and other alternative energy sources can replace current fossil fuels, thereby reducing emissions in the motor vehicle sector. Miklautsch and Woschank (2022) found that significant emission reductions can be achieved by shifting from land to rail transportation. Additionally, research by Ferer and Thome (2023), utilizing a Systematic Literature Review, identified that consolidation, intermodal transportation, and vehicle selection are effective operational measures for carbon mitigation.

Miklautsch and Woschank's (2022) findings highlight the importance of shifting transportation modes from land to rail. Rail transport is considered more efficient and environmentally friendly due to its greater carrying capacity and lower emissions per ton-kilometer compared to land transport. This view is also in line with research by Ferer and Thome (2023), which states that intermodal transportation, combining various modes such as land, rail, and sea, can enhance efficiency and reduce the carbon footprint. Furthermore, the selection of more efficient and environmentally friendly vehicles, such as electric or hybrid vehicles, is another measure that can be taken to reduce emissions in logistics operations. This shift will not only reduce carbon emissions but also decrease traffic congestion and improve overall logistics efficiency.

3. Research Methodology

A qualitative perspective was employed as the philosophical stand for this study, given its exploratory nature. The Delphi method was adopted in this paper. The method was first

developed by RAND Corporation in the 1950s to explore ideas and seek consensus among a panel of experts (Okoli & Pawlowski, 2004). Dalkey on Henning research (2016) The Delphi method is extensively utilized to unify expert opinions on specific subjects in real world contexts . This is accomplished via a sequence of questionnaires that gather data from a chosen group of experts, aiming to reach a consensus (Henning & Jordaan, 2016). The use of this Delphi method is to find out the expert views on carbon emission reduction in the logistics industry. Novakowski and Wellar (2008) explain that there are 3 types of Delphi, the first is regulatory Delphi, which is used to explore "*What should be*" and used to gain consensus about the preferred future. The second is Delphi Forecasting, which is used to make predictions for upcoming events. The third is Political Delphi, which is used to explore an interest with political consequences. Reducing Carbon Emissions in Logistics Industry is part of accounting regulations and strategy, thus this research is a part of the first Delphi group.

3.1 Expert Selection

The selection of the expert group is a critical phase in the Delphi method, significantly influencing its success or failure. The chosen experts largely determine the method's effectiveness, necessitating careful identification of the required characteristics for potential participants. Typically, the most common selection criteria emphasize a deep understanding of the subject matter. According to Kieso, these users include investors (primary users), regulators, preparers, academics, professional associations, financial communities, accounting firms, and business entities (Saptono et al., 2023). Based on this, we adhered to the literature's recommendation to engage experts from various backgrounds with diverse interests to ensure all perspectives are represented.

The number of experts on the panel can differ for various reasons. Numerous studies concur that the panel should comprise at least seven and no more than 25 members (Mateos-Ronco & Torralba, 2019). Having fewer than seven participants raises the risk of statistical error, while exceeding 25 does not significantly enhance the outcomes. At the outset, invitations were extended to 8 chosen experts. The details of these experts' profiles are outlined in Table 1.

In the Delphi method, the number of panelists does not depend on a sample that represents the population but rather on the quality of information provided by the panelists (Castarlenas et al., 2021; Henning & Jordaan, 2016; Okoli & Pawlowski, 2004). The selection of panelists who are experts in the field of logistics ensures that the panelists involved possess deep experience and knowledge related to the topic being studied. Thus, 8 panelists are sufficient to provide comprehensive and diverse insights.

Selecting a smaller but focused number of panelists allows for significant contributions from each expert in the discussion. As explained by Cavalli-Sforza and Ortolano in Novakowski's research (Novakowski & Wellar, 2008), the ideal number of panelists for Delphi ranges between 8 to 12 individuals. Richey, in the same study, also stated that a smaller number of panelists is sufficient to reach a consensus on the questions posed.

Therefore, a smaller number of panelists enables the depth of analysis to be maintained. The opinions, experiences, and insights shared by each panelist can be examined in detail without being overwhelmed by excessive data volume. This approach supports better-quality results and facilitates the achievement of a more accurate and informative consensus.

Table 1. Expert Profiles

No	Background	Affiliation	Experience (Number of Year)	Gender
1	Business Entity	Liquid8	23 Years	Male
2	Business Entity	HAVI	18 Years	Male
3	Business Entity	Indonesian Trucking Organization	47 Years	Male
4	Business Entity	Kompas Gramedia Express & Logistics (KGX)	22 Years	Female
5	Business Entity	Antosim Lampung Pelayaran	30 Years	Male
6	Business Entity	Terminal Teluk Lamong	33 Years	Male
7	Business Entity	SINERGI ID	12 Years	Male
8	Government	Ministry of Finance	12 Years	Male

3.2 Data collection

The researcher began by conducting a literature review from various journals that discuss the factors contributing to carbon emissions, the impact of carbon emissions on the environment and health, methods for reducing vehicle emissions, and the role of regulations in reducing carbon emissions. Based on this review, the researcher developed more focused questions to be asked to the panelists.

In the data collection process, the researcher used the Estimation-Talk-Estimate (ETE) technique. This technique involves three stages. First, the researcher asked the panelists to provide an initial estimate on the questions posed, without offering any guidance or additional information. Then, a discussion was held where the panelists were given the opportunity to consider new factors or other panelists' opinions. Finally, the researcher asked the panelists to provide a revised estimate based on the discussion. This technique aims to improve the accuracy and consensus among the panelists.

Interviews were conducted individually with each panelist over the course of one week. Each interview lasted an average of 1 hour. This technique enabled the researcher to collect rich and in-depth data.

3.3 The questionnaire

The questions posed to the panelists focused on their understanding of carbon emissions within the logistics industry, aiming to gather various perspectives and analyses. The interviews began by asking the panelists about their understanding of carbon emissions and how they perceive its impact on the logistics sector. Following that, the panelists were invited to discuss the main challenges faced by Indonesia in reducing carbon emissions in this sector, including obstacles and opportunities.

The next question highlighted the potential use of rail transport as an alternative mode of land transportation, and how feasible its implementation would be in Indonesia. The panelists were also asked to share their views on the current government regulations regarding carbon emission reduction in the logistics sector, focusing on whether the existing regulations are effective or require improvement. Additionally, the researcher explored the panelists' opinions on the development of Indonesia's logistics industry over the next five years, especially in relation to carbon emission reduction efforts.

Towards the end of the interview, the panelists were asked to provide their views on the most relevant strategies that could be applied in Indonesia's logistics industry. Several options were considered, including the use of electric vehicles (EV), rail transport, and biofuels.

4. Result and Discussion

Based on the interviews conducted with selected experts, including business owners, representatives from the Indonesian Logistics Association, regulators, and academics, the author has identified the impact of technology implementation in reducing gas emissions in Indonesia's logistics sector. The author also found insights into the effectiveness and efficiency of trucking and railways in Indonesian logistics, as well as the factors influencing vehicle selection in the country's logistics system.

4.1 Triangulation

Questions:

1. How familiar are you with the concept of carbon emissions in the context of the logistics industry?
2. What are the main sources of carbon emissions in the logistics industry?
3. Specific steps in your organization to address the carbon emission issue?
4. What are the main challenges faced in Indonesia in carbon reduction efforts?
5. How important is the collaboration between relevant parties?

Table 2. Triangulation of Expert 1 to Expert 4

Question No	***Expert 1***	***Expert 2***	***Expert 3***	***Expert 4***
1	Very familiar.	Familiar for a long time.	Familiar, everyone in the industry knows. It is something everyone faces.	High dependence of transport vehicles and lack of standards.
2	Fuel, warehouse, waste, etc.	Power generation; transport, warehousing mainly.	The movement of goods. There are emissions in every step of it.	Packaging and waste. Last mile delivery.
3	EVs such as motorcycles and vans.	Strong monitoring and tracking.	Actively educating members.	Focus on tracking.
4	No standards	Expensive to be greener.	Lack of clear regulations and guidelines.	High costs.
5	Extremely important.	Very important.	It is the only way to progress.	Crucial.

Table 3. Triangulation of Expert 5 to Expert 8

Question No	***Expert 5***	***Expert 6***	***Expert 7***	***Expert 8***
1	We understand the nature and implications.	Very familiar.	We understand it, it is a key concern for us.	Familiar with the concept, not specialty in logistics though.

2	Usage of fossil fuels.	Movements in all parts of the supply chain.	The activity of vehicles, and other logistics assets.	Economic activity. It occurs because of our movement.
3	Initiatives such as the RORO project.	Strong commitment and goals to sustainability.	Thorough review and evaluation of our current operations.	Strategic and measured policies to facilitate greener technologies.
4	Lack of clear regulatory standards.	Limited renewable energy infrastructure.	No industry standards, as of yet.	Extremely high costs, and wide funding gap.
5	Very important to make clear progress.	Crucial.	It is paramount.	Important, collaboration is important for collective progress.

4.2 The Impact of Technology Implementation in Reducing Gas Emissions in Indonesia's Logistics Sector.

Experts agree that the use of electric vehicles (EVs) is a crucial step towards encouraging companies to shift to more environmentally friendly energy sources. EVs are considered a long-term solution that can significantly reduce carbon emissions within Indonesia's logistics industry. This finding aligns with literature suggesting that EVs have substantial potential to cut carbon emissions in the transportation sector (ALICE, 2019; Browne et al., 2012; Colicchia et al., 2013; Herold & Lee, 2017; Patil, 2021). All interviewed experts are highly optimistic that the adoption of electric vehicles (EVs) can reduce the carbon emissions generated by existing logistics processes in Indonesia.

The use of the latest vehicles, coupled with the adoption of biofuels or other alternative fuels, can also mitigate carbon emissions, such as with trucks equipped with Euro 4 technology. Euro standards are emission regulations designed to reduce environmental pollution (Crippa et al., 2016). However, currently data from one of the experts say that nearly 75% of trucks in Indonesia still use Euro 2 technology, which is a major concern for both business owners and regulators. Efforts are needed to control the use of Euro 2 trucks to decrease carbon emissions in the logistics sector, in this case, the government has also started to make regulations on the standard use of Euro 4 vehicles, but it is still specifically for private cars only (Asropi & Iskandar, 2019).

Nevertheless, implementation faces significant challenges in Indonesia, particularly concerning charging infrastructure and high initial investment costs. Companies require further support, both in terms of policy and incentives, to facilitate this transition.

4.3 Effectiveness and Efficiency of Trucking vs Railways

The land logistics system in Indonesia has traditionally relied heavily on trucking, primarily due to the flexibility this mode of transportation offers. Trucks can deliver goods to various locations, even in areas with diverse road infrastructure. The use of trucks as the main means of goods transportation is especially popular in Indonesia because they can reach remote areas that are inaccessible to other modes of transport.

In addition to trucks, railways are also part of the land logistics system in Indonesia. However, the use of railways as a primary mode of transportation remains minimal. When comparing trucks and railways, numerous studies have shown that railways are far more effective in reducing carbon emissions (ALICE, 2019; Herold & Lee, 2017; Tomar & Joshi, 2024). Railways, with their large carrying capacity, can transport the same load as a significantly smaller number of vehicles compared to trucks. Consequently, the carbon emissions per kilogram of goods are much lower when using railways compared to trucks.

Moreover, railways have a higher energy efficiency per ton-kilometer, meaning that trains can carry larger loads with lower fuel consumption. This makes railways a more environmentally friendly option in the context of carbon emission reduction. However, the limited infrastructure and reach of railways in Indonesia remain major challenges that hinder their use as a primary mode of transport.

This could be seen as good news for Indonesia's logistics sector; however, unfortunately, the use of railways is not widely favored in Indonesia due to several factors:

1. Flexibility, one of the main obstacles hindering the adoption of railways by the logistics sector in Indonesia is the issue of flexibility. Currently, railway operations are under the control of PT KAI, which implements fixed schedules for all routes. This means that logistics companies must align their shipping schedules with those set by PT KAI, which may not align with their operational needs. This dependency results in reduced productivity and efficiency, as companies cannot independently manage their shipping times. In the logistics sector, time flexibility is crucial, and the inability to adjust delivery schedules can lead to delays that impact on the entire supply chain.

2. Infrastructure, the infrastructure of Indonesia's railways also poses a significant barrier to the implementation of a rail-based logistics system. In countries like the United States, railway infrastructure is highly developed, with networks directly connecting strategic areas such as ports and warehouses. This strong connectivity allows for efficient goods transportation from one point to another without the need for complex modal transfers. In contrast, Indonesia's railway network is still very limited and often does not connect directly to major logistics hubs like ports or warehouses. This limitation means that companies must incur additional costs to transport goods from railway stations to their final destinations using other modes of transportation, such as trucks. As a result, logistics costs are higher, and the benefits of using railways for carbon emission reduction cannot be fully realized.

4.4 Current Regulations

There is a strong consensus among experts that government regulations concerning emission limits and greenhouse gas reporting in Indonesia are still significantly lacking. Experts highlight that the lack of clear policies and the absence of dedicated oversight on carbon emissions have created a substantial gap in efforts to reduce emissions within the logistics sector. Without a specific regulatory body responsible for overseeing and monitoring carbon emissions, the logistics industry lacks clear guidelines or adequate incentives to effectively reduce their emissions.

These findings underscore the urgent need for government intervention in creating a regulatory framework that is not only clear but also measurable and capable of being effectively implemented. In the absence of adequate regulations, many companies tend to overlook the necessity of adopting cleaner and more environmentally friendly technologies, as there is no legal impetus or consequences compelling them to do so. Therefore, the Indonesian government should consider adopting a more proactive approach by emulating best practices from other countries that have successfully reduced carbon emissions through the enforcement of strict emission limits and regular reporting.

In developed countries, such as those in Europe and parts of Asia, stringent emission policies have proven effective in encouraging industries to invest in low-emission technologies and reduce their carbon footprint (Herold & Lee, 2017; Paola et al., 2022). These regulations not only set maximum allowable emission limits but also require companies to regularly report their emissions, allowing the government to monitor compliance and take necessary action if those limits are exceeded. Implementing similar policies in Indonesia could be a crucial step in accelerating the transition of the logistics industry towards more sustainable and low-carbon operations (Yuniza et al., 2021).

Moreover, with clear regulations and strict oversight, the government could also provide appropriate incentives for companies that proactively reduce their emissions, thereby creating a more supportive business environment for the adoption of eco-friendly technologies. Strong and targeted government intervention will be key to ensuring that Indonesia’s logistics sector not only follows global trends in emission reduction but also becomes a leader in creating sustainable logistics practices.

4.5 Factors Influencing Mode Selection in Indonesia's Logistics System

It has been found that companies in Indonesia tend to choose inexpensive and flexible vehicles, such as older trucks, which typically produce higher greenhouse gas emissions. Experts argue that this decision is primarily driven by cost considerations, where companies opt to save on operational expenses even if it means using more polluting vehicles. However, if the government were to provide attractive incentives, such as tax reductions or subsidies for fleet renewal to low-emission vehicles, companies would have a stronger motivation to switch to more environmentally friendly transportation technologies.

Although the cost of low-emission vehicles is still relatively high, financial support from the government could reduce the initial burden on companies, making the transition to cleaner technology more economically feasible, this is also in line with the advice of previous research (Altın, 2024; Wan et al., 2022). This discussion highlights that cost is the primary determining factor in companies' decisions regarding the adoption of transportation technology. Financial incentives from the government, such as subsidies or tax reductions, could be highly effective tools in encouraging the adoption of low-emission technology in the logistics sector. This aligns with findings from various previous studies, which indicate that financial incentives significantly boost the adoption of environmentally friendly technologies across different industries. Therefore, such incentive policies would not only assist companies in reducing their environmental impact but also accelerate the achievement of national emission reduction targets.

5. Conclusion

The Paris Agreements, an agreement where Indonesia is a signatory, is a milestone in goal setting and consolidation in one goal to reduce carbon emissions. Logistics is an essential industry; however, it is also one that produces a significant portion of the world's emissions. This study utilized a qualitative method, Delphi, in order to gain expert consensus regarding a critical issue which is the carbon emissions generated by the logistics industry. Numerous experts from diverse backgrounds explained their opinions supported by decades of experience in the logistics industry.

Three initial research questions were the subject of discussion with numerous subject matter experts. Insights from rounds of interviews using the Delphi method uncovered the answers. Our questions, designed to probe into the reality of reducing carbon emissions in the logistics industry and the mechanism best suited to tackle it, are satisfactorily answered in the key insights found from tens of hours of interviews with experts.

Rounds of interviews revealed a consensus among top experts in the logistics industry regarding the ways in which it is most likely to reduce carbon emissions. Key insights are:

1. Consensus regarding the high potential in electric vehicles in Indonesia future logistics development and reduction of carbon emissions.
2. Consensus regarding the need of increased affordability and flexibility in alternative forms of transportation.
3. Consensus regarding the need for robust and supportive regulations in assisting the logistics sector transition to less carbon intensive forms of energy.

Although this research went through an extensive search and selection process for experts, as well as several rounds of interviews, the Delphi method typically benefits from additional rounds of interviews. However, it is important to note that changes in findings may decrease significantly after a certain number of rounds. Despite the comprehensive nature of this study, certain aspects, such as how much electric vehicle (EV) prices need to decrease for a significant transition to occur in the logistics industry, have not been fully explored.

On the other hand, despite various consensuses supporting carbon emission reduction in Indonesia, implementation still faces obstacles, particularly in the logistics and transportation sectors. Policies such as emission reporting, vehicle rejuvenation, and vehicle age limits have not yet been effectively realized. Incentives focused on the use of electric vehicles are still limited to personal vehicles, while the business sector, especially companies that use operational trucks, have not received adequate support. With the high price of electric trucks—ranging from two to three times the price of conventional trucks—the adoption of environmentally friendly technology presents a significant challenge for business actors. Therefore, greater government attention is needed to encourage the use of electric vehicles in the operational sector so that carbon emission reduction targets can be achieved more evenly.

In conclusion, this study examines the need of the logistics industry to reduce its carbon emissions and pairs it with pragmatic opinions of experts with decades of experience to get deeper understanding of key issues and challenges in achieving the Paris Agreement target

6. Implications

This study has two main implications: one for regulators and one for business owners. First, for regulators, which in this context represent the government, there is an urgent need to improve and consistently implement the regulations that have been established. The government must also support the development of adequate infrastructure to facilitate efforts to reduce greenhouse gas emissions resulting from logistics processes. Without sufficient support, the implementation of emission reduction policies will not achieve the desired outcomes.

Second, for business owners, the implication is the importance of adopting more environmentally friendly technologies and practices in their operations. Business owners should consider investing in technologies that can reduce greenhouse gas emissions, even though this may involve higher initial costs. Government support, such as financial incentives or subsidies, can help alleviate the cost burden and encourage the transition to more sustainable solutions.

7. Research Limitation

Every research has limitations, and this study is no exception. The primary limitations of this study include constraints related to the time and availability of the panelists for conducting interviews. Additionally, the limitations of this study pertain to the nature of the Delphi method itself. While the Delphi method is useful for gathering expert opinions, it cannot provide precise estimates of the relative importance of the factors analyzed. This limitation may affect the extent to which the findings of this study can be generalized or used to make decisions based on the factors that were mentioned by the panelist.

As the importance of an energy transition is mounting, with technological limitations and financial implications for businesses being a center of discussion, future research could further explore the implications of energy transition from a company, industry, or country scope as

the technology evolves further. With future accessibility to renewable energy, it is important to update our understanding of how it will impact operational efficiencies, investment strategies, and regulatory frameworks. Future studies might investigate.

1. Adoption strategies: How different sectors are adopting renewable technologies.
2. Economic Impacts: Analysis of the cost-benefit dynamics of transitioning to renewable energy.
3. Policy implications: How governmental policies and incentives can facilitate or hinder the transition.
4. Technological advancements: Exploring emerging technologies and their potential benefits.
5. Case studies: Detailed studies of countries or companies navigated the energy transition.

References

ALICE. (2019). *A framework and process for the development of a ROADMAP TOWARDS ZERO EMISSIONS LOGISTICS 2050*. *December*, 1–40.

Altın, H. (2024). The impact of energy efficiency and renewable energy consumption on carbon emissions in G7 countries. *International Journal of Sustainable Engineering*, *17*(01), 1–9. https://doi.org/10.1080/19397038.2024.2319648

Asropi, D., & Iskandar. (2019). ANALISIS KEPATUHAN MASYARAKAT TERHADAP KEBIJAKAN STANDAR EMISI EURO 4 DI DKI. *Journal of Public Policy and Applied Administration*, *1*(1), 38–49.

Bernardo, V., Fageda, X., & Flores-Fillol, R. (2021). Pollution and congestion in urban areas: The effects of low emission zones. *Economics of Transportation*, *26–27*. https://doi.org/10.1016/j.ecotra.2021.100221

Bouman, E. A., Lindstad, E., Rialland, A. I., & Strømman, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. *Transportation Research Part D: Transport and Environment*, *52*, 408–421. https://doi.org/10.1016/j.trd.2017.03.022

Browne, D., O'Mahony, M., & Caulfield, B. (2012). How should barriers to alternative fuels and vehicles be classified and potential policies to promote innovative technologies be evaluated? *Journal of Cleaner Production*, *35*, 140–151. https://doi.org/10.1016/j.jclepro.2012.05.019

Castarlenas, E., Roy, R., Salvat, I., Montesó-Curto, P., & Miró, J. (2021). Educational needs and resources for teachers working with students with chronic pain: Results of a delphi study. *Sustainability (Switzerland)*, *13*(8), 1–9. https://doi.org/10.3390/su13084510

Climate Transparency. (2022). *Climate Transparency Report: Comparing G20 Climate Action*. 1–

20. https://iesr.or.id/en/pustaka/climate-transparency-report-2022

Colicchia, C., Marchet, G., Melacini, M., & Perotti, S. (2013). Building environmental sustainability: Empirical evidence from Logistics Service Providers. *Journal of Cleaner Production*, *59*, 197–209. https://doi.org/10.1016/j.jclepro.2013.06.057

Crippa, M., Guizzardi, D., & Galmarini, S. (2016). EU effect : Exporting emission standards for vehicles through the global market economy. *Journal of Environmental Management*, *183*, 959–971. https://doi.org/10.1016/j.jenvman.2016.09.068

Damara, D. Y., Wardhana, I. W., & Sutrisno, E. (2017). Analisis Dampak Kualitas Udara Karbon Monoksida (CO)... *Jurnal Teknik Lingkungan*, *6*(1). http://ejournal-s1.undip.ac.id/index.php/tlingkungan

Fang, G., Gao, Z., & Sun, C. (2023). How the new energy industry contributes to carbon reduction? —Evidence from China. *Journal of Environmental Management*, *329*. https://doi.org/10.1016/j.jenvman.2022.117066

Ferdnian, M. (2016). Analisis Uji Emisi Gas Buang Kendaraan Bermotor dan Dampaknya Terhadap Lingkungan di Kota Balikpapan (Kal-Tim). *Transmisi Ed.1*, *12*, 15–24.

Ferrer, A. L. C., & Thomé, A. M. T. (2023). Carbon Emissions in Transportation : A Synthesis Framework. *Sustainability*. https://doi.org/https://doi.org/10.3390/su15118475su15118475 Academic

Gupta, S., Kar, S. K., & Harichandan, S. (2022). India's emerging fuel mix for 2050: actions and strategies to decarbonize the transport sector. *International Journal of Energy Sector Management*, *16*(5), 924–945. https://doi.org/10.1108/IJESM-02-2021-0005

Henning, J. I. F., & Jordaan, H. (2016). Determinants of financial sustainability for farm credit applications: A Delphi Study. *Sustainability (Switzerland)*, *8*(1). https://doi.org/10.3390/su8010077

Herold, D. M., & Lee, K.-H. (2017). *Carbon management in the logistics and transportation sector : an overview and new research directions and new research directions*. *3004*. https://doi.org/10.1080/17583004.2017.1283923

Hodijah, N., Amin, B., & Mubarak, M. (2014). Estimasi Beban Pencemar Dari Emisi Kendaraan Bermotor di Ruas Jalan Kota Pekanbaru. *Dinamika Lingkungan Indonesia*, *1*(2), 71. https://doi.org/10.31258/dli.1.2.p.71-79

ISO - Towards a net-zero logistics sector. (2023). https://www.iso.org/contents/news/2023/01/a-net-zero-logistics-sector.html

Kumar, A. N., Jose, A. S., Tadepalli, N., Babu, V. V. S., Uppalapati, S., & Jani, S. P. (2022). A review on life cycle analysis and environmental sustainability assessment of bio-fuel. In *International Journal of Global Warming* (Vol. 26, Issue 1). https://doi.org/10.1504/IJGW.2022.120069

Lisa Wijayani, Fabby Tumiwa, & IESR. (2022). *Climate Transparency Report 2022*. IESR.

Margaryan, S. (2021). Low emission zones and population health. *Journal of Health Economics*, *76*, 102402. https://doi.org/10.1016/j.jhealeco.2020.102402

Mateos-Ronco, A., & Torralba, N. P. (2019). Sustainable management of contemporary art galleries: A Delphi survey for the Spanish art market. *Sustainability (Switzerland)*, *11*(2). https://doi.org/10.3390/su11020541

Miklautsch, P., & Woschank, M. (2022). A framework of measures to mitigate greenhouse gas emissions in freight transport: Systematic literature review from a Manufacturer's perspective. *Journal of Cleaner Production*, *366*(June), 132883. https://doi.org/10.1016/j.jclepro.2022.132883

Mubarak, A., & Rahman, I. (2020). A comparative analysis of carbon emissions from transportation and logistics of the consumer goods industry in Southeast Asia. *International Journal of Technology*, *11*(2), 333–341. https://doi.org/10.14716/ijtech.v11i2.3466

Novakowski, N., & Wellar, B. (2008). Using the Delphi technique in normative planning research: Methodological design considerations. *Environment and Planning A*, *40*(6), 1485–1500. https://doi.org/10.1068/a39267

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: An example, design considerations and applications. *Information and Management*, *42*(1), 15–29. https://doi.org/10.1016/j.im.2003.11.002

Paola, C., Paipa-sanabria, E., Zapata-cortes, J. A., Aguirre-restrepo, Y., & Quiñones-bolaños, E. E. (2022). *A Review of Economic Incentives to Promote Decarbonization Alternatives in Maritime and Inland Waterway Transport Modes*.

Patil, P. (2021). Sustainable transportation planning: Strategies for reducing greenhouse gas emissions in urban areas. *Eqme*, *1*(1), 116–129.

Placek, M. (2023). *Logistics industry worldwide - statistics & facts | Statista*. Transportation & Logistics. https://www.statista.com/topics/5691/logistics-industry-worldwide/#topicOverview

Reid, W. V., Ali, M. K., & Field, C. B. (2020). The future of bioenergy. *Global Change Biology*, *26*(1), 274–286. https://doi.org/10.1111/gcb.14883

Saptono, P. B., Mahmud, G., Pratiwi, I., Purwanto, D., Khozen, I., Aditama, M. A., Khodijah, S., Wayan, M. E., Asmara, R. Y., & Jie, F. (2023). Development of Climate-Related Disclosure Indicators for Application in Indonesia: A Delphi Method Study. *Sustainability (Switzerland)*, *15*(14). https://doi.org/10.3390/su151410915

Shahboz, A., & Koestoer, R. H. S. (2023). The electric vehicle transition in Russia and Indonesia. *Applied Environmental Science*, *1*(1), 33–45. https://doi.org/10.61511/aes.v1i1.2023.153

Shirvani, S., Baseri, Y., & Ghorbani, A. (2024). Evaluation Framework for Electric Vehicle Security Risk Assessment. *IEEE Transactions on Intelligent Transportation Systems*, *25*(1). https://doi.org/10.1109/TITS.2023.3307660

Tomar, J. S., & Joshi, K. V. (2024). *Strategic for Reducing Carbon Emission and Promoting Eco - friendly Transportation in Logistics Industry*. *13*(4), 325–329.

Wan, B., Wan, W., Hanif, N., & Ahmed, Z. (2022). *Logistics performance and environmental sustainability : Do green innovation , renewable energy , and economic globalization matter ? September*, 1–10. https://doi.org/10.3389/fenvs.2022.996341

Wilczarska, J., Prusiewicz, A., Kuliś, E., & Martinez, J. M. (2024). Analysis of the possibility of using electric vehicles in a transport company. *MATEC Web of Conferences*, *391*, 01016. https://doi.org/10.1051/matecconf/202439101016

Yuniza, M. E., Pratama, I. W. B. E., & Ramadhaniati, R. C. (2021). Indonesia's incentive policies on electric vehicles: The questionable effort from the government. *International Journal of Energy Economics and Policy*, *11*(5), 434–440. https://doi.org/10.32479/ijeep.11453

Zachariadis, T., Ntziachristos, L., & Samaras, Z. (2001). The effect of age and technological change on motor vehicle emissions. *Transportation Research Part D: Transport and Environment*, *6*(3). https://doi.org/10.1016/S1361-9209(00)00025-0