

Electric Vehicle Regulation: Navigating Legal Challenges in Sustainable Transportation Transformation

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Abstract: *The global adoption of electric vehicles (EVs) continues to increase in line with efforts to reduce carbon emissions and achieve sustainable transportation. The Indonesian government targets 2 million electric cars and 13 million two-wheeled electric vehicles by 2030, with various fiscal incentives and subsidies. However, EV adoption still faces major challenges, including high prices compared to conventional vehicles, limited charging infrastructure, and regulations that have not been fully integrated. The complexity of regulations, including the 38 Indonesian National Standards (SNI) that are still voluntary, hinders the acceleration of the EV industry. In addition, regulations related to battery waste management and carbon footprint in electric vehicle production still need to be strengthened. This study uses normative juridical methods with legislative, conceptual, and comparative legal approaches to analyze the effectiveness of EV regulations in Indonesia compared to other countries. The results of the study show the need for regulatory harmonization, the application of the Extended Producer Responsibility (EPR) principle for battery recycling, and the integration of environmental policies in EV development. With more structured policies and collaboration between the government, industry, and society, Indonesia can accelerate the adoption of electric vehicles effectively and sustainably, while reducing environmental impact and increasing the competitiveness of the national industry*

Keywords: *Electric Vehicles, EV Regulation, Sustainable Transportation, Environmental Policy, Regulatory Harmonization.*

INTRODUCTION

The adoption of electric vehicles (EVs) globally shows a significant upward trend, driven by awareness of climate change issues and the need for sustainable transportation. Governments in various countries have implemented policies to encourage the use of EVs, such as tax incentives, subsidies, and investment in charging infrastructure. In Indonesia, the government targets 2 million units of electric cars and 13 million units of two-wheeled electric vehicles to operate on the road by 2030. To achieve this target, the government provides USD 455 million to subsidize the sale of electric motorcycles, including 800 thousand new units



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and the conversion of 200 thousand units of fossil fuel motorcycles. However, EV adoption in Indonesia still faces considerable challenges. One of the main obstacles is the price gap between electric vehicles and

conventional vehicles.¹ The price of EVs is still relatively higher than fossil fuel vehicles, which makes many consumers hesitant to switch. In addition, the still limited charging infrastructure is a significant obstacle. A PwC survey in 2023 shows that consumer concerns about the availability of charging stations as well as maintenance costs, including battery replacement, are the main factors hindering EV adoption.² On the other hand, there are positive developments in the growth of two-wheeled electric vehicles in Indonesia. The population of two-wheeled electric vehicles has increased significantly by 262%, from 17 thousand units in 2022 to 62 thousand units in 2023. However, this figure is still far from the target set by the government. This indicates the need for a more effective strategy to increase the attractiveness of EVs in the domestic market.³

To accelerate EV adoption, collaborative efforts are needed between the government, the private sector, and the community. The government can expand the scope of fiscal incentives, such as a reduction in import taxes on EV components and tax exemptions for electric vehicles, to reduce the price gap. In addition, investment in the development of charging infrastructure should be increased, including the construction of more fast charging stations in different regions.⁴ The private sector also has an important role to play in accelerating EV adoption. Electric vehicle manufacturers can improve production efficiency to reduce costs, as well as work with the government to develop cheaper and more durable battery technology. In addition, transportation and logistics companies can start switching to using electric vehicles for their operations to encourage wider use of EVs. Public awareness also needs to be increased through educational campaigns about the benefits of electric vehicles, both in terms of operational cost efficiency and contribution to the environment. With synergy between various stakeholders, it is hoped that EV adoption in Indonesia can grow more rapidly and support the achievement of the targets that have been set, thereby bringing long-term benefits to the environment and the national economy.

The complexity of regulation and standardization of electric vehicles (EVs) in Indonesia reflects significant challenges in efforts to achieve sustainable transportation transformation. Although the government has established 38 Indonesian National Standards (SNI) related to EVs, which cover aspects from components to batteries, the implementation of these standards is still voluntary. This raises questions about the effectiveness of the standard in ensuring the safety, performance, and interoperability of electric vehicles in the domestic market. Additionally, differences in charging methods and a lack of adequate infrastructure add layers of complexity, hindering widespread EV adoption.⁵

¹ Tangkudung, A. G. (2024). Jejak Sejarah Mobil Listrik di Indonesia: Perkembangan dan Tantangan. *Syntax Idea*, 6(9), 6087-6096.

² Indonesia Electric Vehicle Consumer Survey 2023, <http://pwc.com/id/en/publications/automotive/indonesia-electric-vehicle-consumer-survey-2023.pdf>

³ Widjaya, D. (2023). *Strategi Intervensi Pemerintah Daerah Dalam Pengelolaan Sampah di Kabupaten Bekasi Provinsi Jawa Barat* (Doctoral dissertation, Sekolah Tinggi Ilmu Pemerintahan Abdi Negara).

⁴ Anastasya, R., & Putri, S. B. (2024). SDGs 7: Efektivitas Program Penggunaan Bus Listrik Guna Mendorong Transportasi Publik Ramah Lingkungan. *Journal of Environmental Economics and Sustainability*, 1(3), 13-13.

⁵ Panjadinata, N. A. (2024). Analisis Dampak Kebijakan Pembangkit Listrik Tenaga Surya Atap Pln Terhadap Pengembangan Energi Terbarukan: Tantangan Dalam Harmonisasi Regulasi Investasi Energi Terbarukan. *Commerce Law*, 4(2), 488-506.

To overcome this obstacle, harmonization of regulations at the national and international levels is imperative. BSN has adopted 33 of the 38 EV-related SNIs from international standards such as ISO and IEC, indicating an early step towards global compatibility. However, without strong enforcement and mandatory enforcement, these standards may not achieve the desired impact. In addition, the active involvement of various stakeholders, including government, industry, and consumers, is necessary to ensure that the standards set not only meet technical needs but can also be applied practically in the field. This collaborative approach will help create a more integrated and efficient EV ecosystem, driving faster and more effective sustainable transportation transformation.⁶

Law Number 32 of 2024 concerning Amendments to Law Number 5 of 1990 concerning the Conservation of Biological Natural Resources and Their Ecosystems emphasizes the importance of natural resource conservation as an integral part of environmental protection efforts. Although this law does not specifically regulate electric vehicles (EVs), the principles contained in it have significant relevance to the development and regulation of EVs in Indonesia. The development of EVs is in line with conservation goals through the reduction of greenhouse gas emissions and air pollution, which in turn supports the preservation of ecosystems and biodiversity.⁷

Effective implementation of Law No. 32 of 2024 can encourage the adoption of more environmentally friendly transportation technologies, such as EVs, by ensuring that existing policies and regulations support innovation without sacrificing conservation principles.⁸ Hal ini mencakup penyusunan standar dan regulasi yang memastikan produksi, penggunaan, dan pembuangan EV serta komponennya, seperti baterai, tidak menimbulkan dampak negatif terhadap lingkungan. Dengan demikian, harmonisasi antara regulasi EV dan UU konservasi akan menciptakan kerangka kerja yang komprehensif untuk mencapai transportasi berkelanjutan dan pelestarian lingkungan.

METHOD

The research method in the study "Electric Vehicle Regulation: Navigating Legal Challenges in Sustainable Transportation Transformation" uses a normative juridical method, which focuses on the analysis of regulations and legal principles related to electric vehicles. The statute approach is used to review various regulations, such as Law No. 32 of 2024 concerning the environment and Presidential Regulation No. 55 of 2019 concerning the acceleration of battery-based electric vehicles.

In addition, a conceptual approach is applied to understand the legal principles underlying EV regulation, including environmental legal theories and consumer protection. The comparative approach is also used to compare Indonesian regulations with those of other countries, such as the European Union and the United

⁶ Anugrah, D. F., Rishanty, A., Rahmawati, D., & Tjahjono, B. (2025). Navigating the path to a greener future: unravelling the challenges and prospects of electric vehicle adoption in Indonesia. *Journal of Enterprise Information Management*.

⁷ Mulyono, A. T. (2022). Dinamika Hukum Konservasi Alam sebagai Fenomena dalam Pembangunan Ibu Kota Negara. *Majalah Hukum Nasional*, 52(1), 1-25.

⁸ Tilly, N., Yigitcanlar, T., Degirmenci, K., & Paz, A. (2024). How sustainable is electric vehicle adoption? Insights from a PRISMA review. *Sustainable Cities and Society*, 105950.

States, in order to find a more effective legal model. In its analysis, this study utilizes primary legal materials, such as laws; secondary legal materials, such as journals and research reports; and tertiary legal materials, such as legal dictionaries. With this method, the research aims to provide policy solutions that can accelerate the adoption of electric vehicles effectively and sustainably in Indonesia.

RESULTS AND DISCUSSION

Regulatory Challenges in the Implementation of Electric Vehicles in Indonesia

1. Regulatory Inconsistency between the Central and Regional Governments

The lack of regulatory synchronization between the central and regional governments is one of the main obstacles in the implementation of electric vehicles in Indonesia. Although the central government has issued policies such as Presidential Regulation No. 55 of 2019 concerning the acceleration of electric vehicles, its realization at the regional level still faces various obstacles.⁹ One of the main problems is the difference in the provision of tax incentives and subsidies. The central government has provided exemption from Sales Tax on Luxury Goods (PPnBM) and a reduction in Motor Vehicle Name Return Duty (BBNKB), but not all regions have implemented similar policies. For example, DKI Jakarta has implemented a BBNKB of 0% for electric vehicles, while in many other regions, electric vehicle taxes are still charged at a higher rate or the same as fossil fuel vehicles. Fiscal incentive policies play a key role in driving the adoption of electric vehicles, with countries with strong tax incentives such as Norway and Germany experiencing significant increases in electric vehicle sales compared to countries with weaker incentives.¹⁰ This inconsistency causes people's interest in electric vehicles to be diverse, depending on the area where they live.

In addition to tax incentives, other obstacles that arise are related to the infrastructure of Public Electric Vehicle Charging Stations (SPKLU). The central government has encouraged the acceleration of SPKLU construction through the Minister of Energy and Mineral Resources Regulation No. 13 of 2020, but its realization in the regions still faces many obstacles.¹¹ Some regions do not have clear licensing regulations for the construction of SPKLU, so the process is slow. In addition, not all regions have enough budget and investment support to build SPKLU independently. As a result, electric vehicle charging facilities are still concentrated in big cities such as Jakarta, Bandung, and Surabaya, while in other areas the number is still very limited. According to a study from the International Energy Agency (IEA, 2022), the existence of adequate charging infrastructure is one of the main factors in increasing the adoption of electric vehicles. Countries with extensive charging networks, such as China and the Netherlands, are showing rapid growth

⁹ Subiantoro, H., & Maharani, A. E. P. (2024). Analisis Perpres Nomor 55 tahun 2019 Terkait Program Kendaraan Listrik Dalam Rangka Mewujudkan Transportasi Ramah Lingkungan. *Jurist-Diction*, 7(1).

¹⁰ The Limits of Indonesia's Legal Framework for Electromobility: Regulatory and Sustainable Issues

¹¹ Aditty, A. P., & Terapan, M. E. (2024). Kebijakan Kendaraan Bermotor Listrik Berbasis Baterai (KBLBB) dalam Transisi Energi di Indonesia. *Jurnal Analisis Kebijakan Ekonomi*.

in the use of electric vehicles as users feel more confident in traveling long distances.¹² This infrastructure limitation is the main inhibiting factor in accelerating the adoption of electric vehicles, because people still find it difficult to access charging facilities.

In the public transportation sector, regulatory inconsistencies are also seen in policies related to electric vehicles for public transportation. Some regions, such as Jakarta, have begun to adopt electric buses in their public transportation systems, for example through the Transjakarta electric program. However, in other regions, there are no regulations that encourage the use of electric vehicles in public transportation. This shows that local government policies in supporting electric vehicles are still very diverse and have not been standardized nationally. The transition of electric vehicles in the public transportation sector requires integrated regulations and equitable incentives so that transportation operators have investment certainty.¹³ Without uniform regulations, the acceleration of electrification of public transportation will run sporadically and inefficiently. These policy differences cause the electric vehicle ecosystem to develop at a different pace in each region, which ultimately hampers efforts to accelerate the adoption of electric vehicles nationally.

This regulatory inconsistency is caused by several main factors. First, there is a lack of coordination between the central and regional governments in the formulation of electric vehicle policies. Regulations set by the central government are often not followed by clear technical guidelines for local governments, so their implementation is slow and ununiform. According to the public policy theory of Sabatier & Mazmanian (1980), successful policy implementation depends on regulatory clarity and support from various actors, including local governments and the private sector.¹⁴ Second, there are differences in fiscal capacity and infrastructure between regions and each other. Regions with large budgets tend to be more prepared to adopt electric vehicle policies, while regions with limited budgets face challenges in providing incentives and building supporting infrastructure. Third, each region has the authority to set regional taxes and levies, which causes inconsistencies in the implementation of electric vehicle incentives.

This regulatory inconsistency has a negative impact on the development of electric vehicles in Indonesia. One of the most significant impacts is the emergence of uncertainty for investors and automotive industry players. Manufacturing companies and charging infrastructure providers are hesitant to invest because the rules are not uniform and often change in each region. Regulatory uncertainty is one of the main factors hindering investment in the electric vehicle sector, as investors tend to choose markets with more stable and consistent policies.¹⁵ In addition, the slow implementation of regulations in several regions has caused

¹² Nugroho, B., & Angela, D. (2024). Strategi NGO Lingkungan Greenpeace Indonesia Dalam Mendorong Transisi Energi Baru dan Terbaharukan (EBT) di Tengah Kontroversi Realisasi Net Zero Emission (NZE) 2060 di DKI Jakarta. *Ganaya: Jurnal Ilmu Sosial Dan Humaniora*, 7(3), 164-181.

¹³ Sidabutar, V. T. P. (2020). Kajian pengembangan kendaraan listrik di Indonesia: prospek dan hambatannya. *Jurnal Paradigma Ekonomika*, 15(1), 21-38.

¹⁴ Nurnaningsih, N. (2024). Implementasi Kebijakan Elektronifikasi Bea Perolehan Hak Atas Tanah dan Bangunan (EBPHTB) pada Badan Pendapatan Daerah Kota Baubau. *Administratio Jurnal Ilmiah Ilmu Administrasi Negara*, 143-150.

¹⁵ Kusumaningtyas, A. N. (2024). UPAYA MITIGASI EMISI KARBON: SEBERAPA SERIUSKAH INDONESIA?. In *Prosiding Seminar Sosial Politik, Bisnis, Akuntansi dan Teknik* (Vol. 6, pp. 28-40).

the adoption of electric vehicles in Indonesia to be uneven, so that the benefits of this energy transition have not been felt optimally.¹⁶ Not only that, the gap in the provision of infrastructure and incentives also makes people in some regions less interested in switching to electric vehicles, because there is still uncertainty regarding the cost of ownership and the availability of supporting facilities.

To overcome this problem, strategic steps are needed that can harmonize regulations between the central and regional governments. One solution that can be applied is to make derivative policies or special instructions that bind local governments in implementing more uniform regulations. In addition, the central government needs to increase coordination with local governments through a more intensive regulatory consultation mechanism, so that the policies implemented can be adjusted to the conditions of each region without hindering the adoption of electric vehicles. Another step that can be taken is to provide incentives to regions that are active in supporting electric vehicles, for example through additional budgets for the construction of SPKLU or subsidies for electric vehicles in public transportation. In addition, education and socialization to local governments about the economic and environmental benefits of electric vehicles is also very important so that they are more proactive in supporting this policy. According to a study from the United Nations Environment Programme (UNEP, 2021), intensive education and socialization to local governments and communities is one of the main factors in the successful implementation of electric vehicle policies in various developing countries.

With the harmonization of regulations between the central and regional governments, the adoption of electric vehicles in Indonesia can grow faster and more evenly. More uniform regulations will provide certainty for investors and industry players, as well as increase public confidence to switch to electric vehicles. In addition, with more equitable infrastructure support and incentives, the transition to electric-based transportation will be easier, so that Indonesia can achieve its emission reduction and dependence on fossil fuels more effectively..

2. Regulatory Limitations in EV Battery Waste Management

Regulations governing the management of electric vehicle (EV) battery waste are still limited, causing various challenges in environmental, economic, and social aspects. Currently, many countries, including Indonesia, do not have specific policies that regulate the overall EV battery recycling mechanism. One of the main limitations is the lack of implementation of the Extended Producer Responsibility (EPR) scheme, which should require electric vehicle manufacturers to be responsible for the management of their used batteries. Lithium-ion batteries used in electric vehicles contain valuable elements such as lithium, cobalt, and nickel, which if not recycled properly can pose a risk of environmental pollution as well as loss of

¹⁶ Nugroho, B., & Angela, D. (2024). Strategi NGO Lingkungan Greenpeace Indonesia Dalam Mendorong Transisi Energi Baru dan Terbaharukan (EBT) di Tengah Kontroversi Realisasi Net Zero Emission (NZE) 2060 di DKI Jakarta. *Ganaya: Jurnal Ilmu Sosial Dan Humaniora*, 7(3), 164-181.

reusable resources.¹⁷ As a result, many used batteries end up in landfills without safe treatment, increasing the risk of environmental pollution due to heavy metal content that can seep into soil and water sources.

The lack of regulation also has an impact on the slow development of infrastructure and recycling technology. In the absence of an obligation for the industry to establish a sustainable waste management system, manufacturers are more likely to produce new batteries than to recycle old ones. This not only leads to an increase in hazardous waste, but also increases the dependence on new raw materials, most of which are still imported. Battery recycling technology can save up to 40% of energy compared to the production of new batteries, as well as significantly reduce the carbon footprint of the electric vehicle industry.¹⁸ However, without policies that encourage investment in the recycling industry, the use of this technology is still very limited in many developing countries. If regulations governing recycling are not implemented immediately, in the long run the country will face challenges in meeting the needs of the battery industry in a sustainable way.

In addition to environmental and economic impacts, regulatory limitations also pose social risks. In some cases, battery waste is often managed by the informal sector without adequate safety standards, so workers can be exposed to hazardous substances that impact their health. Exposure to heavy metals from lithium-ion batteries can cause health problems such as kidney damage, neurological disorders, and respiratory diseases if managed unsafely. In addition, the lack of public awareness about the dangers of used batteries also exacerbates this problem, as many batteries are thrown away carelessly or sold without going through proper recycling mechanisms.

To address this problem, the government needs to immediately adopt a clear EPR policy and require electric vehicle manufacturers to be responsible for managing their battery waste. In addition, regulations should encourage the development of recycling infrastructure and provide incentives for industries investing in used battery processing technology. Some countries such as the European Union and China have implemented strict policies regarding EV battery recycling, which according to a report by the International Energy Agency (IEA) has managed to increase the recycling rate by up to 50% in recent years. No less important, public education about the dangers of battery waste and the importance of recycling must be strengthened so that public awareness increases. With this comprehensive approach, the risk of environmental pollution can be reduced, economic opportunities in the recycling industry can be maximized, and negative social impacts due to battery waste can be minimized.

¹⁷ Costa, C. M., Barbosa, J. C., Gonçalves, R., Castro, H., Del Campo, F. J., & Lanceros-Méndez, S. (2021). Recycling and environmental issues of lithium-ion batteries: Advances, challenges and opportunities. *Energy Storage Materials*, 37, 433-465.

¹⁸ Dimiyati, A. F., Silvi Istiqomah, S. T., Wahyuni, A. E., Mubarak, Z., Umma, N. R., & Hilda, R. N. (2024). *Baterai Kendaraan Listrik dalam Perspektif Sustainability*. MEGA PRESS NUSANTARA.

Harmonization of Electric Vehicle Regulations with Law No. 32 of 2024

1. Integration of Electric Vehicle Regulations with Environmental Conservation Principles

The integration of electric vehicle regulations with the principles of environmental conservation in Law No. 32 of 2024 concerning Environmental Protection and Management is very important so that electric vehicles truly contribute to sustainable transportation. One of the main aspects that must be considered is the reduction of carbon emissions in the production of electric vehicles. Although electric vehicles do not produce emissions when in use, their production process, especially in the manufacture of batteries, still has a large carbon footprint. A study revealed that lithium-ion battery production accounts for about 150–200 kg of CO₂ per kWh of battery capacity produced, with most of the emissions coming from the extraction and processing of raw materials. If the energy source used in manufacturing comes from fossil fuel power plants, then the environmental benefits of electric vehicles become less significant. Therefore, regulations must encourage the use of renewable energy in the production process as well as provide incentives to manufacturers who implement low-carbon standards, such as those that have been implemented in the European Union through the EU Battery Regulation (2023) which sets carbon footprint thresholds in battery production.¹⁹

In addition, battery waste management is a major challenge in the electric vehicle ecosystem. Electric vehicle batteries have a limited lifespan and contain heavy metals such as lithium, cobalt, and nickel that can pollute the environment if not managed properly. Used lithium-ion batteries can release toxic substances such as lithium hexafluorophosphate and heavy metals into the environment if not recycled properly. Without an effective recycling system, battery waste will pose a serious threat to the sustainability of the ecosystem. Therefore, regulations need to adopt the principle of Extended Producer Responsibility (EPR), where manufacturers are obliged to manage their battery waste by providing recycling facilities and used battery collection programs. For example, Norway has implemented an EPR system that requires manufacturers to collect and recycle more than 50% of electric vehicle batteries produced since 2020, which has been proven to reduce toxic waste and improve the efficiency of material utilization. The standardization of used battery storage, transportation and processing systems must also be strictly regulated to avoid soil and water pollution.

Furthermore, ecosystem protection from the exploitation of natural resources for battery raw materials is also a crucial factor. The main raw materials for batteries, such as lithium, cobalt, and nickel, are generally obtained through mining activities that risk causing deforestation, water pollution, and social conflicts in mining areas. A study by the Global Battery Alliance (2023) notes that more than 70% of the world's cobalt supply comes from the Democratic Republic of the Congo, where unsustainable mining practices have led to soil degradation, water pollution, and child labor exploitation. If not properly regulated, the increase in demand for electric vehicles can actually exacerbate the environmental impact due to unsustainable extraction of natural resources. Therefore, regulations must ensure that mining practices are carried out

¹⁹ Panjadinata, N. A. (2024). Analisis Dampak Kebijakan Pembangkit Listrik Tenaga Surya Atas PIn Terhadap Pengembangan Energi Terbarukan: Tantangan Dalam Harmonisasi Regulasi Investasi Energi Terbarukan. *Commerce Law*, 4(2), 488-506.

with the principles of sustainability, including the implementation of post-mining land reclamation and the protection of biodiversity in affected areas.

Without a clear policy integration between electric vehicles and environmental conservation principles, there is a risk that electric vehicles will only be a partial solution that still has a negative impact on the ecosystem. Currently, electric vehicle policies focus more on accelerating adoption and economic incentives without considering the overall ecological impact. The lack of supporting infrastructure, such as battery recycling facilities and low-carbon production standards, is also an obstacle to realizing truly environmentally friendly electric vehicles. Therefore, electric vehicle regulation must be integrated in a holistic approach that covers the entire vehicle life cycle, from the production process, use, to waste management. Thus, electric vehicles can be a sustainable transportation solution that not only reduces carbon emissions but also ensures the protection of the ecosystem in the long term.

2. Strengthening Environmental Standards in the Electric Vehicle Industry

Strengthening environmental standards in the electric vehicle industry is a crucial aspect in ensuring that the transition from fossil fuel vehicles to electric vehicles truly has a positive impact on the environment. Strict regulations are needed to cover the entire life cycle of electric vehicles, from the production process, energy use, to waste management.²⁰ In the context of Law No. 32 of 2024 concerning Environmental Protection and Management, regulations must ensure that electric vehicles not only reduce carbon emissions when in use, but also during the production and disposal stages. One of the main challenges in the electric vehicle industry is the carbon footprint still generated in the extraction process of raw materials such as nickel and lithium, which are used in batteries. A study conducted by the International Council on Clean Transportation (ICCT) (2021) shows that the production of electric vehicle batteries can produce significant carbon emissions if fossil-based energy sources are still used. Therefore, strengthening environmental standards must start from the use of renewable energy in production facilities, so that greenhouse gas emissions can be significantly reduced.

In addition, the use of electricity from clean energy sources to charge electric vehicles is also an important factor in strengthening the environmental standards of this industry. If electric vehicles still depend on electricity from fossil fuel plants such as coal, then the benefits in reducing carbon emissions will be less than optimal. Based on the International Energy Agency (IEA) report (2023), electric vehicles charged with renewable energy-based electricity can reduce CO₂ emissions by up to 80% compared to fossil fuel vehicles throughout their life cycle. Regulations should encourage the development of charging infrastructure based on renewable energy, such as those that rely on solar or wind power, as well as provide incentives to companies that implement more efficient battery technology innovations. The higher the efficiency of the battery, the lower the energy consumption required, so it can contribute to long-term energy sustainability. A study from Nature Climate Change (2022) also emphasizes that improving battery efficiency and using

²⁰ Berliandaldo, M., & Prasetyo, A. (2022). Analisa dan Tinjauan Hukum atas Kebijakan Pengembangan dan Pemanfaatan Kendaraan Bermotor Listrik pada Sektor Pariwisata Indonesia. *Sanskara Hukum Dan HAM*, 1(02), 01-12.

more environmentally friendly materials can reduce environmental impact by up to 50% compared to previous generation batteries.

On the other hand, the problem of waste from electric vehicles must also be a major concern in strengthening environmental standards. The recycling of batteries and vehicle components must be strictly regulated to avoid pollution due to toxic waste, especially from lithium-ion batteries that contain hazardous materials if not managed properly. A study from the Journal of Industrial Ecology (2023) revealed that without a good recycling system, electric vehicle battery waste can increase environmental pollution by up to three times compared to conventional vehicles in the long term. Regulations can implement the Extended Producer Responsibility (EPR) mechanism, which requires electric vehicle manufacturers to be responsible for the recycling process of their products. With an effective recycling system, battery materials can be reused, reducing the need for new raw material extraction and reducing environmental impact.

However, the implementation of these stricter environmental standards is inseparable from various challenges. The production cost of electric vehicles could increase due to the implementation of more complex green standards, potentially affecting the selling price of electric vehicles in the market. In addition, the limited renewable energy infrastructure can be an obstacle in ensuring that electric vehicles operate fully with clean electricity. One major obstacle in the transition to electric vehicles is the availability of renewable energy-based power grids, which still require large investments to increase their capacity.²¹ Another difficulty is building a broad battery recycling ecosystem, considering that recycling technology still requires large investments to be applied effectively.

However, the benefits of strengthening environmental standards far outweigh the challenges. By ensuring that the entire supply chain of the electric vehicle industry implements green practices, Indonesia can accelerate the clean energy transition and reduce dependence on fossil fuels. Strict regulation will encourage innovation in the automotive and energy sectors, creating a more competitive and sustainable market. To support the implementation of this policy, the government needs to provide incentives for the automotive industry to implement green practices, as well as tighten supervision of corporate compliance in meeting environmental standards. If the strengthening of these standards can be carried out properly, then the electric vehicle industry will not only be a solution in reducing vehicle emissions, but also part of global efforts to maintain environmental sustainability.

CONCLUSIONS

The implementation of electric vehicles in Indonesia still faces significant regulatory challenges, especially in policy harmonization between the central and regional governments. Regulatory inconsistencies hinder investment, infrastructure development, and the adoption of electric vehicles by the public. In addition, the lack of regulations related to battery waste management poses a serious environmental risk, as there is no effective and sustainable recycling system. Regulations also need to pay attention to the carbon footprint of electric vehicle production, especially in the battery manufacturing process that still depends on

²¹ Mahdavian, A., Shojaei, A., McCormick, S., Papandreou, T., Eluru, N., & Oloufa, A. A. (2021). Drivers and barriers to implementation of connected, automated, shared, and electric vehicles: An agenda for future research. *Ieee Access*, 9, 22195-22213.

intensively exploited natural resources. Therefore, the implementation of low-carbon standards and the use of renewable energy in the production of electric vehicles is very important. Economic incentives and the availability of charging infrastructure still need to be increased to accelerate the adoption of electric vehicles in the community. On the other hand, cybersecurity in electric vehicles that are increasingly connected to digital systems also needs attention in regulations. The application of the Extended Producer Responsibility (EPR) principle must be carried out to ensure that manufacturers are responsible for recycling used batteries. With more integrated policies, electric vehicles can be a sustainable transportation solution that reduces carbon emissions while protecting the environment. All regulations must refer to Law No. 32 of 2024 concerning Environmental Protection and Management to ensure the sustainability of the ecosystem. If these challenges can be overcome, Indonesia has great potential to become a leader in the electric vehicle industry in the region.

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