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Reformulation of Legal Regulations for Battery-Based Electric Vehicle Use and Battery Waste Management in Indonesia

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Abstract: *This study aims to analyze and propose reforms to the legal regulations governing the use of battery-based electric vehicles and the management of battery waste in Indonesia, from the perspectives of environmental law and sustainable development. The method used is a normative juridical approach, with a legislative and conceptual approach, based on a review of Law Number 32 of 2009, Government Regulation Number 22 of 2021, and Presidential Regulation Number 55 of 2019. The results indicate that existing legal regulations remain sectoral, do not fully accommodate the battery life-cycle approach, and contain inconsistencies and gaps in norms, particularly regarding producer responsibility and post-use battery waste management. These conditions have the potential to create environmental pollution risks and legal uncertainty amidst the accelerating energy transition. Therefore, an integrative legal reformulation based on the principles of sustainable development, a circular economy, and Extended Producer Responsibility is needed through the establishment of specific regulations, strengthening oversight mechanisms, and developing a national battery recycling industry to achieve effective and equitable environmental protection.*

Keywords: *battery-based electric vehicles, battery waste, legal reformulation, sustainable development*

Introduction

The global energy transition from fossil fuels to clean energy is an inevitability driven by the climate change crisis and international commitments, particularly through the Paris Agreement, which Indonesia ratified through Law Number 16 of 2016. (Al Huda, 2023) This commitment demands a significant reduction in greenhouse gas emissions, including from the transportation sector, which has been a major contributor. (Setyono, 2021) In this regard, battery-based electric vehicles are positioned as a strategic solution for decarbonizing transportation. However, the increase in the production and use of lithium-ion batteries globally has given rise to new problems, including battery waste, which could become a negative externality of the energy transition. (Rahma, 2025) Normatively, this condition underscores the need to balance the goal of reducing emissions with the obligation to protect the environment, as mandated in Article 28H, paragraph (1), of the 1945 Constitution of the

Republic of Indonesia, which guarantees the right to a good and healthy environment. (Octavianie, 2025)

In the national context, the Indonesian government has established a policy direction to accelerate the adoption of electric vehicles through Presidential Regulation Number 55 of 2019, which sets out the acceleration of the battery-based electric motor vehicle program for road transportation. (Pramudya, 2024) This policy is reinforced by various derivative regulations issued by relevant ministries and is closely linked to the downstreaming of mineral resources, particularly nickel, which serves as the primary raw material for batteries. However, the policy orientation tends to emphasize industrial growth and investment rather than strengthening environmental protection, particularly in post-use battery waste management. (Hermawati, 2024) This indicates an imbalance between energy and environmental policies, which legally has the potential to conflict with the principles of sustainable development as stipulated in Article 2(a) of Law Number 32 of 2009, which emphasizes the principle of state responsibility.

Scientifically, electric vehicle batteries—especially lithium-ion batteries such as NMC and LFP—contain various hazardous and toxic materials, including nickel, cobalt, and lithium, which can pollute soil, water, and air if not managed properly. (Nur, 2021) From an environmental law perspective, battery waste substantially meets the criteria for hazardous and toxic waste as stipulated in Article 1, number 21 of Law Number 32 of 2009, and further detailed in Government Regulation Number 22 of 2021. (Sri, 2025) However, the main challenge lies in the technical complexity of battery waste recycling and processing, which requires advanced technology and high costs, potentially leading to management practices that do not comply with environmental standards. (Nauri, 2024) This condition shows a gap between general legal norms and the need for more specific regulations regarding electric vehicle battery waste.

From a legal perspective, the regulation of hazardous and toxic waste in Indonesia encompasses licensing, transportation, processing, and landfill management, and applies environmental legal principles such as the precautionary principle, the polluter-pays principle, and strict liability, as reflected in Article 88 of Law Number 32 of 2009. (Hidayah, 2023). However, in practice, there are no explicit, comprehensive regulations governing the end-of-life of electric vehicle batteries, including manufacturers' responsibilities for waste collection and processing. (Dimyati, 2024). This indicates a normative gap and disharmony between sectors, particularly between energy, industrial, and environmental policies, which have implications for weak legal certainty and the effectiveness of battery waste management.

This problem is further complicated by practical obstacles, including the lack of domestic battery recycling facilities, limited human resources and technology, and the potential for illegal practices in hazardous and toxic waste management. Furthermore, Indonesia also faces the risk of becoming a dumping ground for battery waste from other countries, which is expressly prohibited by Law Number 18 of 2008 and various international instruments. (Barus, 2024) Compared to the European Union, which has developed a circular economy-based Battery Regulation and strictly implemented Extended Producer Responsibility, Indonesia still lags behind in terms of preventive and systemic

regulations. (Prasyanti, 2025) This gap demonstrates the need to learn from international best practices to strengthen the national legal framework.

Based on this description, it can be concluded that the current legal approach is unable to address the complexity of electric vehicle battery waste resulting from the energy transition. Therefore, a reformulation of legal regulations is needed that is not only sectoral but also integrates energy law and environmental law, prioritizing the principles of sustainable development, a circular economy, and the protection of environmental rights. Theoretically, this reformulation can be based on a green constitution approach, progressive law, and the concept of ecocracy, which places the environment as a subject that must be protected. Thus, this research has urgency and scientific significance in addressing the normative gap and in formulating a more responsive, adaptive, and equitable legal regulatory model for electric vehicle battery waste management in Indonesia.

Methodology

This research employs a normative juridical research method that focuses on legal norms as an autonomous system through an examination of primary, secondary, and tertiary legal materials, positioning law as a rule written in legislation and as a doctrine developed within legal science. The approach employed includes a statute approach, which examines various relevant regulations, including the 1945 Constitution of the Republic of Indonesia, Law Number 32 of 2009, Law Number 30 of 2007, Presidential Regulation Number 55 of 2019, and Government Regulation Number 22 of 2021, to identify inconsistencies, disharmonies, and gaps in norms governing the use of battery-based electric vehicles and their waste management. In addition, a conceptual approach was used by examining relevant legal concepts, principles, and theories, such as the principle of sustainable development, the polluter pays principle, the precautionary principle, as well as the circular economy and green constitution approaches, to develop a systematic and comprehensive legal argument. The analysis of legal materials was conducted qualitatively using legal interpretation and prescriptive argumentation methods to generate recommendations for reformulating legal regulations that are more responsive, integrative, and equitable for managing electric vehicle battery waste in Indonesia.

Result and Discussion

Legal Construction of Battery-Based Electric Vehicle Use and Its Implications for Battery Waste Management in Indonesia

The legal framework for the use of battery-electric vehicles in Indonesia is primarily built on sectoral policies aimed at accelerating the energy transition and strengthening the national industry, as reflected in Presidential Regulation Number 55 of 2019. This regulation emphasizes industrial development, incentives, and accelerating the adoption of electric vehicles, but has not comprehensively integrated battery waste management as a logical consequence of the increased use of this technology. From an environmental law perspective, this condition indicates a regulatory approach that remains partial, as it has not internalized all environmental impacts within a single, comprehensive legal framework. Whereas, constitutionally, Article 28H paragraph (1) of the 1945 Constitution of the Republic of Indonesia affirms the right of every person to a good and healthy environment,

which should be the basis for every development policy, including the development of battery-based electric vehicles. (Prasyanti, The Urgency of Establishing a Special Law on Battery-Based Electric Motor Vehicles (KBLBB) as a Preventive Measure Against Environmental Pollution in Indonesia, 2025)

Within the environmental legal framework, the management of electric vehicle battery waste should be subject to the environmental protection and management regime as stipulated in Law Number 32 of 2009. This law defines hazardous and toxic waste in Article 1, number 21, as the residue of a business and/or activity containing B3 (hazardous and toxic materials), which, due to its nature, concentration, and/or quantity, can pollute and/or damage the environment and endanger human health. In this context, electric vehicle batteries containing heavy metals such as nickel, cobalt, and lithium are substantially B3 waste. Article 59, paragraph (1) of the law requires anyone who produces B3 waste to manage the waste they produce, which includes reduction, storage, collection, transportation, utilization, processing, and/or landfilling. However, this regulation remains general and does not specifically address the unique characteristics of electric vehicle battery waste. (Ma'arif, 2025)

More technical regulations regarding hazardous and toxic waste are stipulated in Government Regulation Number 22 of 2021, which implements Law 32 of 2009. In this regulation, battery waste can, in principle, be categorized as hazardous and toxic waste based on its hazardous and toxic characteristics. The regulation also governs business licensing, environmental approvals, and procedures for hazardous and toxic waste management in detail. However, a problem arises: the lack of a specific classification for electric vehicle battery waste as a separate category, potentially creating legal uncertainty in its implementation. Furthermore, the approach still focuses on waste management after generation (an end-of-pipe approach), rather than on comprehensive product life-cycle management (a life-cycle approach). (Adi, 2024).

The study argues that the current end-of-pipe regulatory approach is insufficient because it addresses environmental impacts only at the waste stage. Therefore, this study proposes a battery life-cycle regulatory framework covering extraction, manufacturing, distribution, reuse, recycling, and final disposal. The framework includes environmental due diligence for mining activities, sustainability standards in manufacturing, extended producer responsibility (EPR), certification for second-life battery use, mandatory recycling obligations, and strict hazardous waste management standards. Through this integrated approach, regulation operates preventively across the entire battery value chain, thereby enhancing sustainability, legal certainty, and industrial accountability.

When analyzed from a life-cycle perspective, the existing legal framework is unable to accommodate all stages of the electric vehicle battery life cycle, including production, distribution, use, and post-use (end-of-life). Presidential Regulation Number 55 of 2019 focuses more on developing the electric vehicle ecosystem and the battery industry, without explicitly stipulating manufacturers' responsibility for post-delivery battery management. This contrasts with the concept of Extended Producer Responsibility (EPR), which places manufacturers as responsible for the entire product life cycle. This lack of regulation

indicates a significant regulatory gap, particularly in anticipating the future increase in battery waste volume. (Persada, 2026)

From an environmental law perspective, Law Number 32 of 2009 adopts several important principles, including the polluter-pays principle, the precautionary principle, and strict liability. For example, Article 88 of the law stipulates that anyone whose actions use hazardous and toxic materials (B3), produce, and/or manage hazardous and toxic waste that poses a serious threat to the environment, is strictly liable for any losses incurred without the need for proof of fault. However, in the context of electric vehicles, these principles have not been specifically operationalized in sectoral regulations, potentially creating a gap between legal norms and their implementation in practice. This shows that the integration between energy law and environmental law is still weak. (Siombo, 2025)

Based on this analysis, it can be concluded that the legal framework for the use of battery-electric vehicles in Indonesia remains sectoral and has not been comprehensively integrated into the environmental legal regime, particularly regarding battery waste management. The disharmony between Presidential Regulation Number 55 of 2019, Law Number 32 of 2009, and Government Regulation Number 22 of 2021 demonstrates that the existing legal approach is unable to address the complexity of electric vehicle battery waste. Therefore, legal reconstruction is needed through a systemic, integrative approach, adopting a life-cycle perspective and strengthening producer responsibility to achieve sustainable environmental protection.

Disharmony and Normative Voids in the Regulation of Electric Vehicle Battery Waste as a Problem in Environmental Law

Disharmony and normative voids in the regulation of electric vehicle battery waste in Indonesia are a consequence of technological developments that are not simultaneously accompanied by adequate legal reforms. Within the positive legal framework, Law Number 32 of 2009 provides a general basis for B3 waste management, particularly through Article 59, paragraph (1), which requires every producer of B3 waste to manage its waste. However, this norm remains generic and does not specifically regulate the characteristics of electric vehicle battery waste, which is highly complex in both its chemical composition and processing technology. This absence of specific norms creates a legal gap in anticipating the surge in battery waste as electric vehicle adoption increases.

This regulatory gap is further evident in the absence of explicit regulations governing end-of-life battery management. Presidential Regulation Number 55 of 2019 focuses on accelerating the development of the electric vehicle industry and its adoption, without imposing explicit legal obligations for the collection, recycling, or processing of used batteries. Yet, from a modern environmental law perspective, regulating the entire product life cycle is essential. Empirically, this situation is becoming evident in the absence of an integrated national system for collecting used electric vehicle batteries, potentially leading to uncontrolled disposal by end users.

Furthermore, another significant weakness is the suboptimal implementation of the Extended Producer Responsibility (EPR) principle in the management of electric vehicle battery waste. Although the concept of producer responsibility is well established in waste

management policies, its implementation in the context of electric vehicle batteries lacks a robust legal and operational foundation. Law Number 18 of 2008 recognizes the principle of producer responsibility, but does not specifically address electric vehicle batteries. Empirically, electric vehicle manufacturers in Indonesia lack a clear legal obligation to recall or recycle end-of-life batteries, resulting in the management burden being shifted to consumers or even overlooked altogether.

Regulatory disharmony is also evident in the overlapping authority between ministries and institutions, particularly between the Ministry of Energy and Mineral Resources, the Ministry of Environment and Forestry, and the Ministry of Industry. Government Regulation Number 22 of 2021 grants the Ministry of Environment and Forestry (KLHK) significant authority over the management of hazardous and toxic waste, while policies on the battery and electric vehicle industries are coordinated by other ministries. This lack of synchronization leads to weak coordination in policy formulation and implementation. Empirically, this is reflected in the lack of uniform national standards for the collection, storage, and recycling of electric vehicle batteries, as well as the suboptimal reporting and oversight system across sectors.

Weaknesses in the oversight and law enforcement system also exacerbate this problem. Although Law Number 32 of 2009, through Articles 76 to 95, regulates administrative, civil, and criminal law enforcement instruments, its implementation still faces various obstacles, such as limited supervisory resources, weak institutional capacity, and low levels of business compliance. Empirically, hazardous and toxic waste management practices in Indonesia are still frequently plagued by violations, including illegal waste disposal and substandard management. In the context of electric vehicle battery waste, the problem is exacerbated by the high economic value of battery components, which can encourage informal practices that pose environmental risks.

From a comparative legal perspective, the European Union has developed a more comprehensive regulatory framework through a circular economy approach that requires manufacturers to be responsible for the entire battery life cycle, including collection and recycling obligations. This model demonstrates that specific and integrated regulations can minimize environmental risks while promoting resource efficiency. Compared with this approach, Indonesian positive law lags behind and is not yet adaptive to developments in electric vehicle technology. Therefore, the disharmony and lack of established norms are not only normative issues but also have created real empirical problems, necessitating comprehensive, integrative, and responsive legal reforms to address environmental challenges in the energy transition era.

Reformulation of Legal Regulations for Electric Vehicle Battery Waste Management Based on the Principles of Sustainable Development and a Circular Economy

Reformulation of legal regulations for electric vehicle battery waste management must begin with a constitutional affirmation that environmental protection is a fundamental right of citizens, as stipulated in Article 28H paragraph (1) of the 1945 Constitution of the Republic of Indonesia, and the state's obligation to manage natural resources sustainably, as reflected in Article 33 paragraph (4). Within this framework, legal reformulation can no

longer be sectoral but must integrate energy and environmental law regimes. A concrete action that needs to be taken is the creation of special regulations (lex specialist) on the management of electric vehicle battery waste that comprehensively regulate the entire battery life cycle, from production to post-use. This regulation could take the form of a special law or, at a minimum, a new government regulation that explicitly addresses the gaps in Law Number 32 of 2009 and Government Regulation Number 22 of 2021.

Furthermore, the reformulation must establish Extended Producer Responsibility (EPR) as the primary, binding, and operational norm. In this regard, regulations are needed that require electric vehicle manufacturers and importers to be responsible for post-life battery management, including mandatory take-back systems, recycling, and waste processing. Concrete actions include establishing legal obligations, such as minimum targets for battery collection and recycling rates, and mandatory periodic reporting to the government. Furthermore, incentive and disincentive schemes should be implemented, such as imposing administrative fines on manufacturers that fail to meet EPR obligations and providing fiscal incentives for businesses developing battery recycling technology.

From a circular economy perspective, legal reformulation should encourage the development of a national battery-recycling industry within the electric vehicle ecosystem. This can be achieved through concrete policies, such as mandatory recycled-content requirements for the production of new batteries and the establishment of dedicated industrial zones for battery waste processing. The government also needs to establish national standards for environmentally friendly battery recycling and waste management technologies. To support this, collaboration between the government, the private sector, and research institutions is needed to increase domestic technological capacity, eliminating Indonesia's dependence on foreign technology for battery waste management.

Reformulation must also include strengthening oversight mechanisms and making them more effective. Although Law Number 32 of 2009 regulates law enforcement instruments through Articles 76 to 95, its implementation needs to be strengthened with a more adaptive approach to technological developments. Concrete actions that can be taken include developing a digital tracking system to monitor battery movement from upstream to downstream, increasing the capacity of environmental supervisory officials, and establishing a special cross-ministerial task force to oversee the management of electric vehicle battery waste. Furthermore, enforcement of the strict liability principle, as stipulated in Article 88, must be optimized to ensure firm legal accountability for polluters.

Harmonizing cross-sectoral regulations is also a crucial step in this legal reformulation. To address overlapping authority between ministries, a clear coordination mechanism is needed, for example, by establishing a special agency or by strengthening the role of a coordinating ministry with integrative authority. Another concrete action is to synchronize regulations between Presidential Regulation Number 55 of 2019 and environmental regulations, so that battery waste management becomes an integral part of the national electric vehicle policy. Furthermore, existing regulations need to be revised to include specific provisions for managing electric vehicle battery waste.

Theoretically, this reformulation should be based on a green constitution approach, progressive law, and the concept of ecocracy, which positions the environment as an entity that must be protected equitably. Within this framework, the law functions not only as a control tool but also as a social engineering instrument to encourage behavioral change toward sustainability. Concrete actions include incorporating circular-economy principles and environmental protection into legal education curricula and public policy, and increasing public participation in overseeing battery waste management. Thus, this legal reformulation is expected to create a responsive, adaptive, and ecologically just legal system to address the challenges of Indonesia's energy transition.

Conclusion

Based on the discussion as a whole, it can be concluded that the legal framework for electric vehicle battery waste management in Indonesia remains fragmented, lacks clear norms, and adopts a sectoral regulatory approach, thereby failing to address the complexity of the environmental risks posed by the development of electric vehicle technology. Although there is a legal basis in Law Number 32 of 2009 and Government Regulation Number 22 of 2021, as well as the policy to accelerate electric vehicles through Presidential Regulation Number 55 of 2019, these regulations do not specifically and comprehensively address the life cycle of electric vehicle batteries, particularly the end-of-life phase. The absence of regulations on producer responsibility, weak integration across sectors, and suboptimal law enforcement indicate that Indonesian positive law is not yet well adapted to the new challenges of the energy transition. Therefore, legal reform is needed, grounded in the principles of sustainable development, a circular economy, and the protection of environmental rights as guaranteed by the 1945 Constitution of the Republic of Indonesia.

In line with these conclusions, it is recommended that the government immediately reform the law by establishing special regulations (lex specialis) that comprehensively regulate the management of electric vehicle battery waste, adopting a life-cycle approach and the principle of Extended Producer Responsibility, and making them strictly binding. Furthermore, cross-sectoral regulatory harmonization among energy, industrial, and environmental policies is needed, as is strengthening oversight and law enforcement mechanisms through technology and institutional capacity building. The development of a national battery recycling industry should also be encouraged as part of implementing a circular economy, accompanied by incentives and clear technical standards. Furthermore, public and business participation must be strengthened in battery waste management to create a transparent and accountable system. With these steps, it is hoped that the legal reformulation will create a fair, sustainable, and responsive electric vehicle battery waste management system that addresses technological developments and environmental protection needs in Indonesia.

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