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Regulatory Gaps and the Emerging Risk of Electric Vehicle Battery Fires in Indonesia

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Original Article

Abstract

The development of electric vehicles (EVs) in Indonesia is experiencing a positive trajectory; however, the risk of battery-related fires remains a significant challenge that is not yet comprehensively addressed within the national regulatory framework. This study aims to assess the effectiveness of Indonesia's legal framework in mitigating the risk of EV battery fires by analyzing regulatory implementation, technical challenges, and the extent of consumer legal protection. A normative legal approach is employed, focusing on the analysis of national laws and regulations alongside relevant international standards. The findings reveal that existing national regulations remain fragmented and insufficiently responsive to the rapid advancements in battery technology, particularly concerning safety testing protocols and thermal risk management. When compared to international standards such as UNECE Regulation No. 100 and UL 2580, Indonesia's legal framework demonstrates a substantial need for harmonization. In conclusion, the study highlights the urgent need for adaptive, integrated, and risk-based regulatory reforms to ensure consumer safety while simultaneously enhancing the competitiveness of Indonesia's electric vehicle industry in both domestic and international markets.

Keywords: *Legal Protection, Battery Safety, Regulatory Standards, Electric Vehicles*

Abstrak

Perkembangan kendaraan listrik (EV) di Indonesia menunjukkan tren positif, namun risiko kebakaran akibat kegagalan baterai masih menjadi tantangan serius yang belum sepenuhnya terakomodasi dalam regulasi nasional. Penelitian ini bertujuan untuk menganalisis efektivitas kerangka hukum Indonesia dalam mengurangi risiko kebakaran pada baterai EV, dengan mengkaji aspek implementasi, permasalahan teknis, dan perlindungan hukum konsumen. Pendekatan yuridis normatif digunakan dengan menganalisis peraturan perundang-undangan nasional dan standar internasional yang relevan. Hasil penelitian menunjukkan bahwa regulasi nasional masih bersifat parsial dan belum responsif terhadap perubahan teknologi baterai, terutama dalam aspek pengujian keselamatan dan manajemen risiko termal. Dibandingkan dengan standar seperti UNECE R100 atau UL 2580, kerangka hukum Indonesia masih membutuhkan harmonisasi. Kesimpulannya, diperlukan regulasi yang adaptif, terintegrasi, dan berbasis risiko guna menjamin keselamatan pengguna dan memperkuat daya saing industri kendaraan listrik nasional.

Kata kunci: *Perlindungan Hukum, Baterai, Standar Keselamatan, Kendaraan Listrik*

1. INTRODUCTION

The global automotive industry is undergoing a significant transformation toward cleaner and more sustainable mobility systems. Among the key pillars of this transition is the advancement of electric vehicle (EV) technology, driven by increasing awareness of climate change and the urgent need to reduce carbon emissions from the transportation sector. Electric vehicles, which rely primarily on battery power, offer an alternative to fossil fuel dependence by promoting energy efficiency and substantially reducing greenhouse gas emissions. Beyond environmental benefits, this transition presents opportunities for green economic development and the growth of high-technology industries.

In Indonesia, the adoption of electric vehicles is gaining momentum, as reflected by a steady rise in EV usage and supportive government policies, including tax incentives, investment facilitation, and the expansion of charging infrastructure. The Indonesian government has set an ambitious target: by 2025, approximately 20% of vehicles on the road are expected to utilize environmentally friendly energy sources. Despite this progress, critical challenges remain, particularly concerning the safety of electric vehicle batteries—most notably lithium-ion batteries. While these batteries offer high energy density and efficiency, they are also prone to thermal hazards and malfunctions, which can lead to fires or explosions, especially when subjected to mechanical damage or improper charging.[1]

Numerous incidents involving lithium-ion battery fires have heightened public concern about the safety of electric vehicles. In Indonesia, similar fire incidents involving electric bicycles and smartphones have intensified negative perceptions surrounding this battery technology. In this context, strengthening the regulatory framework governing EV battery safety is essential—not only to protect consumers but also to build public confidence and support the wider adoption of electric vehicles.

Several prior studies underscore the pivotal role of EV adoption in reducing transportation-related greenhouse gas emissions. For example, Júnior et al. highlight the urgent need for regulatory frameworks addressing battery waste management and the implementation of rigorous technical standards to ensure the sustainability of EV battery life cycles.[2] Nuarta and Sukedi analyze Indonesia's legal framework supporting the acceleration of electric vehicle deployment, including policy incentives and infrastructure development.[3] Rudijanto and Sudiro focus more specifically on the risks

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1 Yuqing Chen et al., "A Review of Lithium-Ion Battery Safety Concerns: The Issues, Strategies, and Testing Standards," *Journal of Energy Chemistry* 59 (2021): 83–99, https://doi.org/10.1016/j.jechem.2020.10.017.

2 Carlos Antônio Rufino Júnior et al., "Towards to Battery Digital Passport: Reviewing Regulations and Standards for Second-Life Batteries," *Batteries* 10, no. 4 (2024): 1–53, https://doi.org/10.3390/batteries10040115.

3 I Nengah Nuarta and Mochamad Sukedi, "Kebijakan Hukum Pengaturan Penggunaan Kendaraan Listrik Dalam Penguatan Ketahanan Energi Nasional," *Jurnal Preferensi Hukum* 5, no. 2 (2024): 145–54, https://doi.org/10.22225/jph.5.2.2024.145-154.

of lithium-ion battery fires, emphasizing the need for stringent safety testing as a component of consumer protection mechanisms.[4] In a broader international context, Mathur et al. and Visvikis shed light on the fragmented nature of EV safety regulations across the European Union and advocate for harmonized international standards to bridge existing regulatory gaps.[5]

These studies collectively reveal that safety and technical regulation of EV batteries remains a significant challenge, necessitating further investigation tailored to evolving technologies and national contexts. Despite valuable contributions from prior research, there is a noticeable gap in the literature concerning the effectiveness of EV battery safety regulation implementation in Indonesia. Few studies critically examine the extent to which current policies address the specific technical risks posed by lithium-ion batteries, particularly in light of the country's broader agenda to scale up its domestic EV industry. Moreover, the issue of aligning national regulations with international standards has not been sufficiently explored, representing an underdeveloped area in academic discourse.

This study seeks to fill this research gap by assessing the effectiveness of Indonesia's regulatory mechanisms in mitigating fire risks associated with EV batteries. The analysis focuses on regulatory implementation, technical safety concerns, and consumer protection. Furthermore, this research explores the potential for harmonizing national policies with international regulatory standards and offers strategic recommendations for strengthening Indonesia's regulatory framework. The ultimate goal is to support the development of a resilient, safe, and sustainable electric vehicle ecosystem that garners public trust and aligns with global technological advancements.

2. RESEARCH METHODOLOGY

This study adopts a normative legal approach, which emphasizes the analysis of statutory laws, regulatory instruments, and legal documents as primary sources of data. This methodology is particularly suitable given the study's objective to evaluate the effectiveness of electric vehicle (EV) battery safety regulations—specifically in mitigating fire risks associated with lithium-ion battery failures in Indonesia—and to assess their alignment with relevant international standards. The legal materials analyzed include domestic regulations such as Presidential Regulation No. 55 of 2019, Government Regulation No. 73 of 2019, and various technical directives issued by the Ministry of Industry and the Ministry of Transportation concerning electric vehicles

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[4] Maria Natasha Rudijanto and Amad Sudiro, "Legality and Safety Regulations of Electric Vehicle Batteries in Indonesia: Challenges and Implementation of National Standards," *Journal of Law, Politic and Humanities* 5, no. 2 (2024): 901–908, https://doi.org/10.38035/jlph.v5i2.1065.

[5] Costandinos Visvikis, "Safety Considerations for Electric Vehicles and Regulatory Activities," in *EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium*, 2012, 1–13; Yash Mathur, Pushpendra Singh, and Yash Kumar Singh, "Safety Issues with Electric Vehicles," *International Journal of Technical Research & Science* 4, no. 10 (2010): 10–12, https://doi.org/10.30780/IJTRS.V04.I10.002.

and their battery systems. In addition, the study reviews international legal instruments and policy documents, including United Nations Economic Commission for Europe (UNECE) regulations, International Organization for Standardization (ISO) standards, and policy frameworks from the European Union and other developed jurisdictions pertaining to battery safety and end-of-life management.

The analytical methods employed encompass descriptive, evaluative, and comparative analyses. Descriptive analysis is used to systematically present the existing legal and regulatory provisions. Evaluative analysis assesses the extent to which current Indonesian regulations effectively address technical safety risks and implementation challenges. Comparative analysis, meanwhile, contrasts national frameworks with international standards to identify regulatory gaps and explore opportunities for policy harmonization. To complement the normative analysis, this study also incorporates a conceptual approach by examining scholarly literature, empirical research, and global best practices related to EV battery safety management. This integrative methodology enables the formulation of policy recommendations that are legally grounded, technologically responsive, and contextually relevant to Indonesia's national priorities in fostering a safe, sustainable, and trustworthy electric vehicle ecosystem.

3. RESEARCH RESULT AND DISCUSSION

3.1. Effectiveness of National Regulations in Mitigating the Risk of Electric Vehicle (EV) Battery Fires

This study examines the effectiveness of Indonesia's national regulatory framework in mitigating the risk of electric vehicle (EV) battery fires, with a particular focus on implementation practices, technical challenges, and consumer legal protection. Within the broader context of transitioning toward low-emission transportation, ensuring battery safety stands as a critical pillar for the successful and widespread adoption of electric vehicles.

The findings reveal that current national regulations concerning EV batteries in Indonesia are not yet fully effective in mitigating fire-related risks. While several key regulations have been enacted—including Presidential Regulation No. 55 of 2019, the Ministry of Energy and Mineral Resources (MEMR) Regulation No. 1 of 2023, and technical standards such as SNI IEC 62660 and SNI 8871:2019—these remain fragmented and sector-specific, lacking comprehensive coverage across the entire battery life cycle. In practice, the implementation of battery safety standards continues to face considerable challenges, such as limited availability of testing infrastructure, a shortage of certified laboratories, and high certification costs that burden manufacturers.

Lithium-ion (Li-ion) batteries—particularly variants such as LFP, NCA, and LTO—dominate EV battery usage in Indonesia due to their high energy efficiency.

However, these battery types also present significant thermal runaway risks.[6] Each battery chemistry carries distinct safety profiles, which ideally require differentiated, risk-based regulatory treatment. However, the existing legal framework does not clearly delineate technical or administrative procedures based on battery type.

This study finds that the regulatory system governing EV battery safety in Indonesia remains in a nascent stage and has not kept pace with the rapid evolution of battery technology. The lack of specific regulations concerning pre-use and post-use battery testing, as well as the absence of a post-market surveillance system, significantly increases the risk of fire or explosion incidents. Furthermore, current national regulations do not provide detailed provisions regarding the legal responsibilities of manufacturers, distributors, or after-sales service providers in the event of battery-related damage or accidents.

These findings align with prior research. For example, Júnior et al. emphasize the necessity of a comprehensive regulatory approach to cover the full EV battery life cycle, including recycling and end-of-life disposal.[7] Similarly, Nuarta and Sukedi highlight the absence of adequate technical regulations in Indonesia to support EV acceleration.[8] Rudijanto and Sudiro point to the insufficient legal attention given to lithium-ion battery fire hazards.[9] Even in the European Union, as noted by Visvikis, EV regulatory frameworks require continuous revision to remain adaptive to technological developments.[10]

The study underscores that regulatory effectiveness is determined not only by the existence of legal norms, but also by the institutional capacity to implement and enforce them. One of the most pressing challenges in Indonesia is aligning domestic safety standards with internationally recognized frameworks such as UNECE Regulation No. 100 (R100), UL 2580, and the EU Battery Directive 2006/66/EC. Harmonization with these standards is essential not only to ensure consumer safety but also to enhance the global competitiveness of Indonesia's EV industry.

Beyond regulatory alignment, the findings also reveal inconsistencies in how technical standards are interpreted by regulators and industry actors. Small and medium-sized enterprises (SMEs), in particular, face difficulties in complying with safety requirements due to limited technical expertise.[11] Meanwhile, consumer awareness

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6 Indra Purnama, "Kelebihan Dan Kekurangan Baterai LFP Alias Lithium Ferro Phosphate: Siklusnya Panjang," Tempo, 2024, https://www.tempo.co/lingkungan/kelebihan-dan-kekurangan-baterai-lfp-alias-lithium-ferro-phosphate-siklusnya-panjang-92231.

7 Júnior et al., "Towards to Battery Digital Passport: Reviewing Regulations and Standards for Second-Life Batteries."

8 Nuarta and Sukedi, "Kebijakan Hukum Pengaturan Penggunaan Kendaraan Listrik Dalam Penguatan Ketahanan Energi Nasional."

9 Rudijanto and Sudiro, "Legality and Safety Regulations of Electric Vehicle Batteries in Indonesia: Challenges and Implementation of National Standards."

10 Visvikis, "Safety Considerations for Electric Vehicles and Regulatory Activities."

11 Anahita Jannesar Niri et al., "Sustainability Challenges Throughout the Electric Vehicle Battery Value Chain," *Renewable and Sustainable Energy Reviews* 191 (2024): 1–15, https://doi.org/10.1016/j.rser.2023.114176; Jigar Sarda

remains limited, with many users lacking access to adequate information about their rights to safe and high-quality EV products.[12]

This study confirms that the current national regulatory framework remains insufficiently effective in mitigating the risks associated with electric vehicle (EV) battery fires. Substantial improvements are required to enhance both safety and consumer protection. To this end, several regulatory and strategic recommendations are proposed:

1) The government should promptly develop specific regulations governing battery safety testing—both prior to market distribution and post-use—by adopting internationally recognized best practices.
2) A nationally accredited and independent battery testing institution should be established, equipped with the technical capacity to conduct comprehensive testing across diverse battery types.
3) Consumer protection measures in the EV sector must be strengthened, encompassing the right to accurate information, guarantees of battery safety, and access to fair compensation mechanisms in the event of incidents or malfunctions.
4) An integrated reporting and product recall system should be embedded within the EV licensing and approval process to ensure accountability on the part of manufacturers and distributors.
5) A collaborative platform involving regulators, academic researchers, and industry stakeholders should be established to periodically revise and update technical standards in line with technological advancements.

By implementing these measures, Indonesia's national legal framework can evolve into a more adaptive, responsive, and consumer-focused regulatory system—capable of addressing the emerging safety challenges posed by EV battery technologies while fostering public trust and sustainable industry development.

3.2. Potential Harmonization of Domestic Policies with International Standards in Regulating Electric Vehicle (EV) Batteries in Indonesia

This study explores the potential for harmonizing Indonesia's domestic policies with international standards in the regulation of electric vehicle (EV) batteries. The primary objective is to develop strategic recommendations that can reinforce the national EV battery regulatory framework, making it more adaptive to technological advancements, technically robust, and operationally effective. The research is driven by the pressing

et al., "A Review of The Electric Vehicle Charging Technology, Impact on Grid Integration, Policy Consequences, Challenges and Future Trends," *Energy Reports* 12 (2024): 5671–92, https://doi.org/10.1016/j.egyr.2024.11.047.

[12] Kantapich Preedakorn, David Butler, and Jörn Mehnen, "Challenges for the Adoption of Electric Vehicles in Thailand: Potential Impacts, Barriers, and Public Policy Recommendations," *Sustainability* 15, no. 12 (2023): 1–21, https://doi.org/10.3390/su15129470.

need to bridge the gap between rapidly evolving battery technologies and a fragmented, overly generalized, and insufficiently integrated national regulatory structure.

The findings indicate that lithium-ion (Li-ion) batteries—particularly variants such as lithium iron phosphate (LFP), nickel cobalt aluminum (NCA), lithium titanate (LTO), lithium manganese oxide (LMO), and lithium cobalt oxide (LCO)—are predominantly used in Indonesia (Purnama, 2024). Each of these battery chemistries exhibits unique technical characteristics in terms of energy density, thermal resistance, charging behavior, and risk of thermal runaway or overcharging. For instance, LFP is noted for its high thermal stability and long cycle life, whereas NCA offers superior energy density but is more susceptible to temperature rise and entails higher production costs.[13]

The analysis further reveals that existing national technical regulations do not yet fully accommodate comprehensive safety testing for EV batteries. Although standards such as SNI IEC 62660 and SNI 8871:2019 provide guidelines for battery cell testing, their practical implementation remains limited, hampered by uneven distribution of certified testing facilities across regions. Other key regulations—such as the Ministry of Energy and Mineral Resources (MEMR) Regulation No. 1 of 2023 and Presidential Regulation No. 55 of 2019—focus primarily on general policy directives and infrastructure development, without addressing specific technical parameters related to battery safety and testing protocols.

The central finding of this study underscores the urgent need to establish an integrated EV battery regulatory system in Indonesia that is responsive to evolving technical standards and technological innovation. Current regulations remain largely sectoral and disconnected, lacking a unified legal framework that holistically ensures battery quality and safety. Moreover, collaboration among regulators, industry stakeholders, and academic research institutions remains suboptimal, impeding the development of science-based, up-to-date safety standards.

Compared with international regulatory frameworks—such as UNECE Regulation No. 100 (R100) in the European Union, UL 2580 in the United States, and China's GB/T 31485—the Indonesian system still lags in both technical scope and implementation. These global standards provide comprehensive safety testing procedures, including evaluations under pressure, extreme temperatures, vibration, mechanical impact, and assessments for potential electrolyte leakage and fire hazards. Prior studies have shown that countries with mature EV industries tend to integrate safety testing into the early stages of product design.[14] In contrast, Indonesia's testing

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[13] Alex K. Koech, Gershom Mwandila, and Francis Mulolani, "A Review of Improvements on Electric Vehicle Battery," *Heliyon* 10, no. 15 (2024): 1–23, https://doi.org/10.1016/j.heliyon.2024.e34806.

[14] E. Cabrera Castillo, "Standards for Electric Vehicle Batteries and Associated Testing Procedures," in *Advances in Battery Technologies for Electric Vehicles*, ed. Bruno Scrosati, Jürgen Garche, and Werner Tillmetz (Amsterdam: Elsevier Ltd, 2015), 469–94, https://doi.org/10.1016/B978-1-78242-377-5.00018-2; Joris Jaguemont and Fanny Bardé, "A Critical Review of Lithium-Ion Battery Safety Testing and Standards," *Applied Thermal Engineering* 231 (2023): 121014, https://doi.org/10.1016/j.applthermaleng.2023.121014; Bhavya Kotak et al., "Battery Crush

regime is often treated as a compliance formality, isolated from the iterative design and engineering process.[15]

These findings suggest that harmonization with international standards is not merely essential for export readiness or integration into the global market, but also serves as a critical mechanism to enhance domestic consumer protection and support a secure and sustainable national energy transition. This harmonization should target three core areas: (1) the substantive content of regulations governing battery safety and technical standards; (2) the establishment of nationally standardized testing and certification systems; and (3) the development of supervisory bodies and testing laboratories that comply with international accreditation requirements.

A risk-based regulatory approach offers a viable strategy for addressing the diverse characteristics of electric vehicle (EV) battery technologies.[16] For instance, NCA batteries, which exhibit a higher likelihood of thermal runaway, should be subject to more rigorous safety testing protocols than LFP variants. Tailoring testing requirements based on the specific risk profiles of each battery type can maximize consumer protection while also optimizing certification costs and timelines.

This study highlights the urgent need to reform Indonesia's EV battery regulatory system to be more technocratic, evidence-based, and aligned with international norms. Harmonization efforts must go beyond administrative or symbolic measures and involve substantive structural changes, including:

1) The revision and integration of currently fragmented regulations into a cohesive national legal framework that comprehensively addresses technical specifications, safety standards, certification processes, and producer liability;
2) The enhancement of national battery testing laboratories through capacity-building in terms of skilled personnel, advanced equipment, and collaborative partnerships with internationally recognized testing institutions;
3) The development of a long-term regulatory roadmap that anticipates future advancements in battery technologies, such as solid-state batteries and ultracapacitors;
4) The active involvement of industry stakeholders, academic experts, and civil society in the regulatory drafting process to ensure that the regulations are reflective of real-world needs and the latest scientific knowledge.

Test Procedures in Standards and Regulation: Need for Augmentation and Harmonisation," *Batteries* 7, no. 3 (2021): 1–28, https://doi.org/10.3390/batteries7030063.

[15] Niklas Tilly et al., "How Sustainable Is Electric Vehicle Adoption? Insights from A PRISMA Review," *Sustainable Cities and Society* 117 (2024): 105950, https://doi.org/10.1016/j.scs.2024.105950.

[16] Shuai Nie et al., "Deciphering Stakeholder Strategies in Electric Vehicle Battery Recycling: Insights from a Tripartite Evolutionary Game and System Dynamics," *Journal of Cleaner Production* 452 (2024): 142174, https://doi.org/10.1016/j.jclepro.2024.142174; Márton Pepó et al., "Advances in Standardised Battery Testing for Enhanced Safety and Innovation in Electric Vehicles: A Comprehensive Review," *Batteries* 11, no. 4 (2025): 1–19, https://doi.org/10.3390/batteries11040157.

By pursuing these strategic directions, Indonesia has the potential to establish a regulatory framework for EV batteries that not only safeguards users and the environment but also enhances the global competitiveness of its domestic EV industry. Adaptive, technically grounded, and operationally effective regulatory harmonization is not a discretionary option—it is a strategic imperative in navigating the ongoing transformation of the electrified automotive sector.

4. CONCLUSION

This study aims to evaluate the effectiveness of national regulations in mitigating the risk of electric vehicle (EV) battery fires in Indonesia, with particular attention to regulatory implementation, technical challenges, and consumer legal protection. In addition, it examines the potential for harmonizing domestic policies with international standards and formulates strategic recommendations to develop a regulatory system that is both adaptive and evidence-based. The findings reveal that, although Indonesia has enacted several EV-related regulations—including Ministry of Energy and Mineral Resources (ESDM) Regulation No. 1 of 2023 and SNI IEC 62660—the current regulatory framework for battery safety remains fragmented and lacks comprehensive provisions for technical testing and fire risk mitigation. Key challenges include a regulatory lag behind the pace of battery technology innovation, underdeveloped testing infrastructure, and limited awareness among industry actors and consumers regarding battery safety. This study underscores the urgent need to revise and update national regulations to align with international standards such as UNECE R100 and UL 2580, thereby ensuring the safety, quality, and accountability of EV products both domestically and in the global market. These findings offer valuable contributions to enhancing consumer protection and improving the competitiveness of Indonesia's electric vehicle industry.

However, this study is limited by restricted access to field data and the absence of direct engagement with regulatory authorities. Future research is therefore recommended to investigate the operational-level implementation of EV battery regulations, including audits of battery testing facilities and oversight of battery distribution practices. As a policy recommendation, the government should prioritize the development of independent, risk-based, and technologically adaptive regulations, while also fostering stronger collaboration among regulatory bodies, industry stakeholders, academic institutions, and testing organizations.

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