

## **Green Criminology Against Environmental Harm and Environmental Crime Policy in Battery-Based Electric Vehicle Projects in Indonesia**

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**Abstract**

Indonesia has promoted battery electric vehicles (BEVs) as a strategy to reduce greenhouse gas emissions. However, environmental harms associated with their life cycle have raised concerns about the sustainability of this transition. This study examined these environmental harms from a green criminological perspective and assessed the effectiveness of Indonesia's environmental criminal law policies in addressing them. A qualitative research approach was employed, combining a systematic literature review of 18 studies, an analysis of national environmental regulations and electric vehicle policies, and interviews with two informants representing an environmental nongovernmental organization and the Ministry of Environment and Forestry. The findings identified several environmental harms, including water contamination, air pollution, soil degradation, and ecosystem destruction, associated with mineral extraction, battery manufacturing, electricity generation, and end-of-life battery management. Dependence on coal-fired electricity and inadequate battery waste management further complicated the potential environmental benefits of BEVs. The policy analysis identified weaknesses in environmental law enforcement, limited public participation in environmental impact assessments, fragmented responsibilities for battery recycling, and insufficient environmental standards across production stages. From a green criminological perspective, the findings demonstrated that even legally authorized industrial activities could generate ecological harm and disproportionately affect local communities, workers, and nonhuman species. The study concluded that the expansion of BEVs in Indonesia required stronger environmental accountability throughout the battery and vehicle life cycles. Comprehensive environmental impact assessments, greater reliance on renewable energy, extended producer responsibility, meaningful public participation, and effective environmental law enforcement were identified as essential measures for advancing an energy transition that supports ecological sustainability and environmental justice.

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### **INTRODUCTION**

In recent years, Indonesia has promoted the development and adoption of electric vehicles (EVs) as part of its national energy transition strategy. This initiative aims to reduce greenhouse gas emissions, decrease dependence on fossil fuels, and support Indonesia's commitments to global climate change mitigation. The transportation sector accounts for approximately 23% of the country's total carbon dioxide (CO<sub>2</sub>) emissions, with emissions exhibiting an increasing trend. According to data from the Ministry of Energy and Mineral

Resources, approximately 11 million cars operate on Indonesian roads, collectively generating more than 35 million metric tons of carbon emissions annually. Furthermore, transportation-related activities reportedly contribute approximately 70%–80% of emissions in certain urban areas (Huda et al., 2025; Prastyono & Sandrina, 2024; Sudjoko, 2021).

In this context, the Indonesian government has established ambitious targets for electric vehicle adoption, including 2 million electric cars and 13 million electric motorcycles by 2030. These targets align with the government's strategy to capitalize on Indonesia's substantial nickel reserves and strengthen its position in the global electric vehicle battery supply chain. The transition to electric mobility is expected to contribute to national emissions reduction commitments, including the previously established target of reducing greenhouse gas emissions by 29%–41% by 2030. Battery electric vehicles (BEVs) produce no direct exhaust emissions during operation, making them a potentially important component of strategies to mitigate climate change and improve urban air quality. However, their overall environmental performance depends on electricity generation sources, battery production processes, and other life-cycle factors (Huda et al., 2025; Kementerian Energi dan Sumber Daya Mineral [ESDM], 2024; Sudjoko, 2021; Wijaya et al., 2023).

To accelerate electric vehicle adoption, the Indonesian government enacted Presidential Regulation No. 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation, subsequently amended by Presidential Regulation No. 79 of 2023. This regulatory framework supports the development of Kendaraan Bermotor Listrik Berbasis Baterai (KBLBB), or battery electric vehicles, through various policy measures. These include vehicle purchase incentives, tax reductions, the development of Stasiun Pengisian Kendaraan Listrik Umum (SPKLU), or public electric vehicle charging stations, and investment incentives for domestic battery manufacturing and downstream mineral processing, particularly nickel-based industries (Aziz et al., 2020; Institute for Essential Services Reform [IESR], 2022; Sudjoko, 2021; Tangkudung, 2024; Wijaya et al., 2023).

The government's policy narrative frequently presents electric vehicles as a cleaner and more environmentally sustainable transportation alternative that can contribute to achieving net-zero greenhouse gas emissions. However, this narrative may insufficiently address the environmental consequences associated with the entire vehicle life cycle, commonly described as a cradle-to-grave assessment. These consequences extend from raw material extraction and battery manufacturing to vehicle operation, battery disposal, and end-of-life recycling. Consequently, evaluating the sustainability of electric vehicles requires consideration of both their potential emissions reduction benefits and the environmental burdens generated throughout their production and use.

From a green criminological perspective, electric vehicle development requires critical examination beyond its stated environmental objectives. White and Heckenberg (2014) emphasized that green criminology extends beyond legally defined environmental crimes to examine environmentally harmful activities that may remain legally permissible (Brisman & South, 2020; Lynch & Stretsky, 2003; South, 1998). This perspective encompasses the concept of "lawful but awful" practices, in which activities authorized under existing regulatory frameworks nevertheless contribute to ecological degradation, environmental victimization, and social injustice. Green criminology also examines the roles of governments, corporations, and regulatory institutions in facilitating, tolerating, or inadequately preventing environmental harm. Accordingly, environmental claims associated with technological innovation should be critically assessed rather than accepted without examining their broader ecological and social

consequences. This framework provides a basis for investigating environmental harm and environmental victimization potentially associated with Indonesia's electric vehicle development initiatives (White & Heckenberg, 2014).

Although battery electric vehicles eliminate direct tailpipe emissions, their production requires substantial quantities of critical minerals, including lithium, cobalt, and nickel. Extracting and processing these materials can contribute to ecosystem degradation, deforestation, water contamination, and other forms of environmental harm when environmental safeguards are inadequate. Mineral extraction may also intensify environmental injustice, particularly when local communities and Indigenous peoples disproportionately experience the environmental and social consequences of mining activities while receiving limited economic benefits. These concerns demonstrate that the environmental implications of electric mobility extend beyond vehicle operation to encompass mineral supply chains and the communities affected by resource extraction (Amnesty International, 2016; Sovacool, 2020).

Indonesia's continued reliance on coal-fired electricity generation presents an additional challenge to the environmental sustainability of electric vehicles. Although battery electric vehicles produce no direct exhaust emissions, their operation generates indirect greenhouse gas emissions when the electricity used for charging originates from fossil fuel-based power plants. Coal-fired power plants, commonly referred to in Indonesia as *Pembangkit Listrik Tenaga Uap* (PLTU), remain a major component of the national electricity generation mix. Consequently, increased electricity demand associated with electric vehicle adoption could contribute to additional fossil fuel consumption and associated emissions, depending on the electricity generation mix and the availability of renewable energy. Nevertheless, these indirect emissions should be evaluated through life-cycle assessment rather than interpreted as evidence that electric vehicles necessarily produce higher overall emissions than conventional internal combustion engine vehicles (Prastyono & Sandrina, 2024).

Therefore, electric vehicle development should be understood not merely as a technological response to climate change but also as a complex industrial transition involving potential ecological contradictions, environmental risks, and distributive justice concerns. This study employed green criminology as a critical framework to examine environmental harm associated with battery electric vehicle projects and assess the adequacy of Indonesia's environmental criminal law policies in addressing such harm. Particular attention was given to Law No. 32 of 2009 concerning Environmental Protection and Management, as amended, and relevant implementing regulations governing mining, industrial activities, and energy development. The analysis considered whether existing regulatory frameworks and enforcement practices adequately prevented environmental degradation or allowed environmentally harmful extractive activities to continue under the justification of green economic development. Through this perspective, the study sought to contribute to a more comprehensive understanding of environmental accountability in Indonesia's energy transition and to support the development of policies that promote ecological protection, environmental justice, and meaningful safeguards for affected communities.

## **RESEARCH METHOD**

This study employed a qualitative research approach to examine the environmental implications of battery electric vehicle (BEV) projects in Indonesia from a green criminological perspective. The research focused on identifying forms of environmental harm occurring throughout the electric vehicle life cycle and evaluating the capacity of Indonesia's

environmental criminal law policies to prevent and address such harm. The qualitative approach facilitated an in-depth examination of environmental issues, regulatory frameworks, and stakeholder perspectives within their social and institutional contexts (Bogdan & Biklen, 1998; Creswell & Poth, 2021).

Data were collected and analyzed using three complementary methods. First, a systematic literature review (SLR) was conducted to synthesize previous research on electric vehicle battery supply chains and their environmental implications. The review included 18 studies addressing environmental impacts associated with mineral extraction, battery production, electricity generation, and end-of-life battery management. The findings were synthesized to identify major forms of environmental harm and the stages of the electric vehicle life cycle associated with significant ecological risks. This approach was informed by the systematic literature review methodology discussed by Snyder (2019).

Second, document analysis was conducted to examine Indonesia's environmental regulatory framework and electric vehicle policies, particularly Law No. 32 of 2009 concerning Environmental Protection and Management, Presidential Regulation No. 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation, and relevant implementing regulations and amendments. The analysis focused on regulatory provisions, environmental protection mechanisms, enforcement arrangements, and potential policy gaps related to environmental harm arising from electric vehicle development.

Third, in-depth interviews were conducted with two key informants to obtain stakeholder perspectives on environmental risks, regulatory implementation, and environmental law enforcement. Informant M, whose identity was withheld for confidentiality, represented an environmental nongovernmental organization and had approximately 20 years of experience in environmental advocacy. Informant X, whose identity was also withheld, represented the Ministry of Environment and Forestry (MoEF). The interviews supplemented the literature review and regulatory analysis by providing institutional and civil society perspectives on the environmental implications of battery electric vehicle projects in Indonesia (Ardiansyah et al., 2023).

## RESULTS AND DISCUSSION

### Overview of Findings

The results of a review of eighteen literature shows that the Battery-Based Electric Motor Vehicle (KLBB) project causes various forms of environmental harm at every stage of the life cycle – from upstream (raw material extraction), production and manufacturing, energy distribution, to downstream (battery disposal/recycling). These findings can be seen as summarized in table 4.1. This study, then, classifies four aspects that are affected by the harm of each stage of the KBLBB life cycle, namely the impact on water, air, soil, and the ecosystem as a whole.

**Table 1.** Classification of Harm Due to Battery-Based Electric Motorized Vehicles (KBLBB)

| Yes | Article Title                  | Author and Year                               | Aspects Affected by Harm      | Forms of Harm                                                                 |
|-----|--------------------------------|-----------------------------------------------|-------------------------------|-------------------------------------------------------------------------------|
| 1   | Powering Principles Businesses | Change: (Amnesty International, 2021) for and | Water (water source), Ecology | Lithium extraction threatens water availability and the fragile ecosystems of |

|   |                                                                                                                                                |                               |                                               |                                                                                                                                                                                                                                                                                                                                                          |
|---|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   | Governments in the Battery Value Chain                                                                                                         |                               |                                               | Indigenous peoples in South America;<br><i>Deep sea mining</i> causes severe and irreversible damage to seafloor ecosystems and the livelihoods of coastal communities.                                                                                                                                                                                  |
| 2 | The Impact of Nickel Mining of PT. Ifishdeco on the Environmental Conditions in Roraya Village, Tinanggea District, South Konawe Regency.      | (Aldiansyah & Nursalam, 2019) | Water, Air, Soil, Ecology                     | Mining practices cause damage to roads and land; Pollution of river/watershed; Air pollution; Damage to flora and fauna.                                                                                                                                                                                                                                 |
| 3 | Environmental Damage Due to Nickel Mining in Kolaka Regency through an Environmental Policy Approach                                           | (Agussalim et al., 2023)      | Water, Ecology                                | Nickel mining waste in Kolaka pollutes the waters and damages coastal ecosystems due to mining material dissolved into the sea.                                                                                                                                                                                                                          |
| 4 | The Impact of the Existence of PT JAM's Nickel Mine on the Social Environment of the Community                                                 | (Dahlan et al., 2025)         | Water, Air, Soil                              | Added waste containing heavy metals (Ni, Co, Fe) pollutes groundwater and surfaces; Mine dust increases airway disorders; The river was polluted with mud and oil, forcing people to turn to drilled wells; Physical damage to the hilly landscape and land around the mine.                                                                             |
| 5 | Environmental impact assessment on production and material supply stages of lithiumion batteries with increasing demands for electric vehicles | (Sakunai et al., 2021)        | Water (pollution and scarcity), Soil, Ecology | Cradle-to-gate <i>greenhouse emissions</i> are fueling global warming and climate change; Metal extraction (Ni, Co, Li, Mn) requires large amounts of water to the point of causing water scarcity and damage to local aquatic ecosystems; Destruction of habitats and ecosystems around mine sites; Recycling practices are limited, many materials are |

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|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                                                                                                                                                                        |                            |                    |       | lost through export, incineration, and disposal.                                                                                                                                                                                                                                                                                                                   |
| 6  | Evaluation of e-waste management in Indonesia                                                                                                                                          | (Paminto et al., 2024)     | Water, Waters      | Soil, | The global e-waste <i>recycling rate</i> is only 20%; the rest is burned or stockpiled, thus causing the emission of toxic substances into the air;<br>Contamination of surface and soil water by plastics and heavy metals (Pb, Cd, Cr, Ni, Zn, Li, Hg, Ag);<br>Serious health impacts on the <i>cardiovascular system</i> , central nervous system, and kidneys. |
| 7  | The Impact of E-Waste on the Environment                                                                                                                                               | (Najicha & Dhinggar, 2019) | Water, Soil        |       | Indonesia's <i>e-waste generation</i> of around 2 million tons in 2021; the process of disposing of Pb-contaminated waste and hazardous substances contaminates soil and groundwater;<br>E-toxic <i>components</i> (HCFCs, PCBs) add toxins to landfills;<br>The <i>melting of chips</i> produces sludge and acid, thus acidifying the soil.                       |
| 8  | The Effects of Electric Vehicle Consumption on the Environment in the Perspective of the Qur'an; M. Qurasy Shihab, Al Zuhaili, and Al-Qurthubi's Interpretation of QS. Ar-Rum Verse 41 | (Harahap et al., 2024)     | Water, Soil        |       | Mining of minerals (Li, Ni, Co) damages the earth's surface and causes <i>deforestation</i> ;<br>Waste batteries contaminate groundwater with toxic chemicals (Ni, La);<br>Human activity and poor battery recycling create an ecological imbalance.                                                                                                               |
| 9  | Are electric cars environmentally friendly?                                                                                                                                            | (Zhou, 2024)               |                    | Air   | Up to 2/3 of the electricity charging of battery-based electric vehicles is still from fossil fuels;<br>Emissions during the manufacturing process of electric cars and batteries increase the carbon footprint.                                                                                                                                                   |
| 10 | Life cycle assessment of electric vehicles and                                                                                                                                         | (Shafique et al., 2022)    | Air, Soil, Ecology |       | Battery production causes air pollution emissions;                                                                                                                                                                                                                                                                                                                 |

|    |                                                                                                                                          |                              |                |       |                                                                                                                                                                                                                                                                                  |
|----|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|----------------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | internal combustion engine vehicles: A case study of Hong Kong                                                                           |                              |                |       | The production of batteries also makes the soil contaminated by toxic substances; Extraction leads to the depletion of natural resources (fossils and rare minerals).                                                                                                            |
| 11 | Global Warming Emissions from Manufacturing Electric Vehicles                                                                            | (Nealer et al., 2015)        | Air, Water     |       | Battery manufacturing contributes to global warming emissions (greenhouse gases) and air pollutants; The life cycle of electric vehicle batteries contributes to water pollution ( <i>eutrophication</i> , <i>acidification</i> ).                                               |
| 12 | Electric Vehicle Batteries Addressing Questions about Critical Materials and Recycling                                                   | (Ambrose & O'Dea, 2021)      | Air, Ecology   |       | Battery and electric vehicle production account for 14-24% of greenhouse gas emissions; Emissions of up to 70 g CO <sub>2</sub> e/mile in battery manufacturing; total of up to 200 g CO <sub>2</sub> e/mile in the U.S.; Mining minerals for batteries causes ecosystem damage. |
| 13 | The Influence of the Nickel Mining Industry on the Maritime Environmental Conditions in Morowali Regency                                 | (Syarifuddin, 2022)          | Water, Ecology |       | Nickel mining practices cause damage to coral reefs; Pollution of marine waters; Degradation of mangrove forests; Sedimentation and mine waste reduce fish catches and disrupt fishermen's livelihoods.                                                                          |
| 14 | Subsidies for Battery-Based Electric Motor Vehicles: How Big Will It Impact on Indonesian People?                                        | (Prastyono & Sandrina, 2024) | Air            |       | Emissions are not significantly reduced because electricity is still fossil source.                                                                                                                                                                                              |
| 15 | Future Projections of Electric Vehicles in Indonesia: A Perspective Analysis of Sustainable Climate Change Impact Control and Regulation | (Nur & Kurniawan, 2021)      | Water, Ecology | Soil, | Soil and water pollution due to waste batteries; Ecosystem damage; Increased carbon emissions and potential damage to landscapes without renewable energy.                                                                                                                       |

|    |                                                                                                                                |                         |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----|--------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16 | Environmental Implications of Electric Cars                                                                                    | (Lave et al., 1995)     | Air, Water       | The release of lead and lead compounds from the manufacture of acid-lead batteries reflects air and water;<br>Neurotoxins damage urban ozone, ecology, and human health;<br>Ni-Cd and NiMH batteries also produce toxic materials.                                                                                                                                                                                             |
| 17 | Global material flow analysis of end-of-life of lithium nickel manganese cobalt oxide batteries from battery electric vehicles | (Shafique et al., 2023) | Air, Water, Soil | Battery metals (Ni, Pb) produce DNA-damaging reactive oxygen species;<br>Electrolytes and toxic organic solutions pollute water and soil;<br>Human health disorders due to exposure to metals and toxic substances.                                                                                                                                                                                                            |
| 18 | Comparative life cycle assessment of conventonal, electric and hybrid passenger vehicles in Spain                              | (Naranjo et al., 2021)  | Air, Ecology     | Electric vehicle battery production accounts for about 55% of greenhouse gas (GHG) emissions;<br>The process of extraction and manufacturing of battery raw materials leads to an increase in fine particle formation by 26%;<br>Increased <i>carcinogenic</i> (20%) and <i>non-carcinogenic</i> (61%) toxicity to humans;<br>Increased <i>terrestrial</i> (31%), <i>freshwater</i> (39%) and <i>marine</i> (41%) ecotoxicity. |

(Source: prepared by the author)

### Impact on Water

A number of studies confirm that the extraction and waste stages of KBLBB batteries significantly threaten water quality and availability. Amnesty International (2021) reported that *lithium extraction* in South America depletes local water sources and damages the fragile ecosystems of indigenous peoples, while *deep-sea mining* causes irreparable damage to seabed ecosystems and coastal fishermen's livelihoods. Research by Aldiansyah and Nursalam (2019) and Agussalim et al. (2023) in Sulawesi confirms that pollution of rivers and watersheds (DASO due to mine waste), while Dahlan et al. (2025) found heavy metals (Ni, Co, Fe) polluting soil and surfaces, forcing communities to turn to borewells. Sakunai et al. (2021) add that the extraction of battery base metals (Ni, Co, Li, Mn) causes local water scarcity, disrupts aquatic ecosystems, and exposes limited recycling practices so that many valuable materials are lost through illegal disposal and exports.

Furthermore, mine waste and *e-waste* also threaten the waters. Paminto et al. (2024) emphasized that the disposal of *e-waste* pollutes surface waters and soil with plastics and heavy metals, thereby increasing harmful bioaccumulation in the aquatic food chain. Meanwhile, Syarifuddin (2022) added that the sedimentation of mine waste damages corals and mangrove forests, causing a decline in fisheries productivity and disrupting the livelihoods of coastal communities.

### **Impact on the Air**

The production and disposal stages of batteries trigger serious air pollution. The manufacturing of Ni-Cd and NiMH batteries, according to Lave et al. (1995), releases lead and *neurotoxins* that pollute the air and damage the urban ozone layer. Nealer et al. (2015) reported significant greenhouse gas (GHG) emissions as well as air pollutants during battery manufacturing, while Ambrose and O'Dea (2021) noted that the production of batteries and electric vehicles accounts for 14–24% of GHG emissions with releases of up to 200 g of CO<sub>2</sub>e per mile. Furthermore, Zhou (2024) and Prastyono and Sandrina (2024) also point out that the coal-based portion of electricity for electric vehicle charging increases overall emissions, thereby nourishing cumulative air pollution in the coal-fired power plant area.

### **Impact on the Soil**

A number of findings highlight soil contamination, both from mine waste and *e-waste*. The results of research by Aldiansyah and Nursalam (2019) and Dahlan et al. (2025) describe landscape damage, mine road erosion, and the accumulation of heavy metal-laden dust and sludge that smokes and acidifies the soil in the area around the mine. Paminto et al. (2024) report that less than 20% of *global e-waste* is recycled, while the rest is burned or stockpiled so that plastics and heavy metals (such as tin, copper, aluminum, cobalt, iron, cadmium, chromium, nickel, zinc, lithium, mercury, and silver) pollute soil and groundwater. This condition causes serious health problems in the nervous and cardiovascular systems of local residents. In addition, Najicha and Dhinggar (2019) added that the melting of electronic components produces toxic and acidic sludge, so it will further acidify and damage soil fertility.

### **Impact on the ecosystem**

Ecological damage is seen on various scales, from land to sea. Amnesty International (2021) showed severe damage to seabed ecosystems due to *deep-sea mining*, while Agussalim et al. (2023) noted that dissolved mining materials are damaging the coastal ecosystem of Kolaka. Then, Sakunai et al. (2021) highlighted deforestation and habitat loss around mines, while Naranjo et al. (2021) explained that the extraction and manufacturing of batteries increases terrestrial ecotoxicity by 31%, freshwater by 39%, and the sea by 41%. Syarifuddin (2022) also found that there is degradation of coral reefs and mangrove forests in Morowali, which has an impact on declining fish catches and damaging fishermen's livelihoods.

### **Analysis Based on Life Cycle Stages**

#### **Upstream Stage (Raw Material Extraction)**

The extraction of nickel, cobalt, and lithium for the manufacture of electric vehicle batteries drains tens of thousands of liters of water per ton of ore, thereby reducing the quality and quantity of groundwater that is the source of livelihood of the indigenous peoples around the mine. Sludge (Aldiansyah & Nursalam, 2019) *tailings* that still contain heavy metals—including Ni, Co, and Fe—are discharged into rivers and watersheds, triggering bioaccumulation in aquatic organisms and polluting surface water. On the other hand, the practice of (Dahlan et al., 2025) *Deep-Sea Mining* for cobalt has damaged seabed ecosystems "legally but destructively", while threatening the livelihoods of traditional fishermen (Amnesty

International, 2016). In the green criminology framework of White and Heckenberg (2014), human (indigenous communities) and non-human (aquatic species) impacts are experiencing cumulative and temporal impacts are delayed, underscoring the importance of reviewing existing mining licensing regimes.

#### 4.2.2. Production and Manufacturing Processes

During the manufacturing stage, the battery *Lithium-Ion* accounts for 14–55% of greenhouse gas emissions *Cradel-to-Gate* and increase the formation of fine particles (PM 2.5) by 26% and *carcinogenic toxicity* by 20%. This process also releases heavy metals such as Pb, Cd, and Cr which pose acute health risks to factory workers and local residents. Although many facilities are located abroad, carbon footprints and pollution are again felt at various points in the supply chain, including Indonesia, so that (Naranjo et al., 2021; Nealer et al., 2015; Shafique et al., 2022)*Harm* Primary has the potential to expand into secondary harm—for example, when industrial emissions regulations are not enforced and victims are forced to take convoluted litigation routes. Potter's (2014) framework highlights that this primary harm is the forerunner of tertiary harm, when unaddressed health and social impacts drive conflict or criminalization of vulnerable groups. Here, the spatial (factory location), scale (global) and temporal (direct and cumulative) dimensions emphasize the need for emission standardization (Ambrose & O'Dea, 2021)*cradle-to-gate*—things that have not been accommodated by Presidential Regulation No. 55/2019.

#### Energy Distribution

Although electric vehicles have zero emissions at the point of use, the majority of electricity for SPKLU in Indonesia is still sourced from coal plants. Emissions of SO<sub>2</sub> (sulfur dioxide), NO<sub>x</sub> (nitrogen oxide), and CO<sub>2</sub> (carbon dioxide) from Steam Power Plants (PLTU) cause large-scale air pollution and burden the health of the people around the plant. In the dimensions described by White and Heckenberg (2014), this is where it can be seen"(Prastyono & Sandrina, 2024; Shafique et al., 2022)*Lawful, but Awful*", where inadequate renewable energy systems reinforce secondary harms, namely chronic health burdens and decreased local economic productivity, as well as tertiary harms in the form of increased social burdens and potential criminalization of vulnerable groups affected by pollution. The scale (regional-national), location (coal), and temporal (sustainable) dimensions demand a more ambitious energy policy in increasing the portion of renewables for SPKLU, something that has so far received minimal attention from regulators.

#### Downstream Stage (Battery Disposal and Recycling)

When batteries reach the end-of-life, less than 20% is formally recycled; the rest is burned or stockpiled in informal landfills, releasing heavy metals and toxic organic compounds into the air, soil, and waters. Under these conditions, informal workers who collect e-waste, without legal protection, face severe toxic exposure, giving rise to secondary harm in the form of long-term damage to health and local ecosystems. If not addressed immediately, this repeated exposure will develop into a theoretical harm: a social burden of health, a decline in quality of life, and potential conflicts related to environmental resources. Potter's (2014) and White and Heckenberg's (2014) frameworks underscore the importance of the (Paminto et al., 2024)*Extended Producer Responsibility* (EPR) to shift the responsibility of recycling from informal communities to producers, closing the downstream regulatory gap that is currently still fragmented.

### Analysis of Environmental Crime Policy Response in Indonesia

The Government of Indonesia has established a major environmental criminal law framework through Law No. 32 of 2009 concerning Environmental Protection and Management, which regulates the obligation of everyone to maintain the preservation of environmental functions and control environmental pollution and/or damage (Article 67). Law No. 32 of 2009 also regulates criminal sanctions – such as fines of up to billions of rupiah and/or imprisonment – for perpetrators of pollution and environmental destruction, ranging from mining to waste disposal. In the environmental crime policy in Indonesia, it actually contains instruments to overcome damage at every stage of the life cycle of electric vehicles. However, both the literature study and the results of interviews with two sources in this study reveal that the implementation and substance of this policy are still far from adequate. Furthermore, the Ministry of Environment and Forestry (MoEF) stated that until now there has been no national *Life Cycle Assessment* study on electric vehicles that covers all their impacts from upstream to downstream (Interview X, 2025).

At the stage of nickel and battery mineral extraction, Law No. 32 of 2009 requires an Environmental Impact Analysis (EIA) for each extractive activity (Articles 22 and 36). If you look at the existing law, AMDAL violations, such as *tailings* disposal without adequate processing, can be subject to criminal sanctions as stated in Article 109 and Article 110. However, in its implementation, the EIA process is often only an "administrative formality" that accommodates corporate interests, not the protection of indigenous peoples around the mine (Interview M, 2025). The Ministry of Environment and Forestry acknowledges that although the regulation of the Minister of Environment and Forestry No. 4 of 2021 requires environmental documents at every stage of extraction, participatory implementation and independent audits are still weak (Interview X, 2025). Thus, primary harms such as water pollution/degradation and potential habitat damage continue without strict sanctions.

At the production and manufacturing stage, Law No. 32 of 2009 sets quality standards for air and liquid limestone emissions (Article 20 and Article 69 paragraph 2), as well as the Minister of Environment and Forestry Regulation No. 4 of 2021 which regulates AMDAL for the battery industry. However, there is no *cradle-to-gate emission standard* that binds manufacturers to measure and control the carbon footprint of batteries as a whole. Interviewee M emphasized that "battery factory electricity is still 60-70% of coal", so that primary and secondary pollution remains high even though electric vehicles are promoted as green solutions (Interview M, 2025). The Ministry of Environment and Forestry added that the Minister of Environment and Forestry Regulation No. 12 of 2021 concerning Lithium Battery Recycling Emission Quality Standards is the first step downstream, but the implementation roadmap is still in process and has not yet fully bound manufacturers (Interview X, 2025).

In energy distribution, Presidential Decree No. 55 of 2019 emphasizes fiscal incentives and the construction of SPKLU without conditions for the use of renewable energy for electric vehicle charging. In fact, the majority of SPKLU electricity is still sourced from coal-fired power plants, which produce *primary harm* in the form of SO<sub>2</sub>, NO<sub>x</sub>, and CO<sub>2</sub> emissions in power plants, as well as *secondary harm* in the form of increased cases of respiratory diseases around coal-fired power plants (Prastyono & Sandrina, 2024; Zhou, 2024). In this regard, the Ministry of Environment and Forestry stated that the commitment *to Net Zero Emission 2060* and the *Just Energy Transition Partnership* (JETP) has not been enough to encourage technical regulations to ensure renewables at SPKLU (Interview X, 2025).

Then, at the downstream stage, Law No. 32 of 2009 and the Minister of Environment and Forestry Regulation No. 6 of 2021 classify lithium batteries as category 1 B3 waste, while the Minister of Environment and Forestry Regulation No. 12 of 2021 sets emission thresholds for the recycling industry. Nonetheless, literature studies show that without the presence of *Extended Producer Responsibility* (EPR), only about 20% of the battery *End-of-life* formal recycling; incineration and informal hoarding of the residue *Harm Primer* (contamination), secondary (toxic exposure of informal workers), and tertiary (long-term health problems). In this regard, our resource persons noted that "the burden of recycling falls on vulnerable communities", while the Ministry of Environment and Forestry emphasized that cross-ministerial coordination for the recycling road map is still ongoing (Najicha & Dhinggar, 2019; Paminto et al., 2024)*Fragmented* (Interview M, 2025; Interview X, 2025). Thus, overall, although criminal and administrative frameworks are available, weak and persistent implementation *Regulatory gaps* (study *cradle-to-gate*, EPR, and *Renewables* for SPKLU) to maintain the *Environmental Harm* the "*Legal but awful*".

## CONCLUSION

Indonesia's transition toward Kendaraan Bermotor Listrik Berbasis Baterai (KBLBB), or battery electric vehicles (BEVs), has been promoted as a strategic initiative to support sustainable development and reduce greenhouse gas emissions. Through Presidential Regulation No. 55 of 2019, as amended by Presidential Regulation No. 79 of 2023, the government has encouraged the development of the electric vehicle ecosystem through fiscal incentives, infrastructure investment, and industrial development policies. Electric vehicles have frequently been presented as symbols of a cleaner, more efficient, and technologically advanced transportation future. However, the findings of this study revealed that this narrative did not fully account for the environmental consequences associated with the electric vehicle life cycle, including raw material extraction, battery manufacturing, electricity generation, and end-of-life battery management.

From a green criminological perspective, the study identified environmental harm across multiple stages of the KBLBB life cycle and highlighted potential structural weaknesses in policies and regulatory practices intended to ensure ecological protection and environmental justice. At the upstream stage, the extraction and processing of critical minerals, particularly nickel, cobalt, and lithium, were associated with risks of water contamination, habitat destruction, ecosystem degradation, and disruption of local and Indigenous communities' livelihoods. Although environmental impact assessment, known in Indonesia as Analisis Mengenai Dampak Lingkungan Hidup (AMDAL), constitutes an important regulatory instrument, the findings raised concerns about limited public participation and insufficient independent assessment of ecological risks. These conditions illustrated how environmentally harmful activities could remain legally authorized despite their potential ecological and social consequences, reflecting the green criminological concept of "lawful but awful" practices.

At the battery manufacturing stage, energy-intensive industrial processes were associated with greenhouse gas emissions and potential releases of hazardous substances. The findings highlighted regulatory challenges concerning the assessment and management of cradle-to-gate emissions, particularly when manufacturing facilities depended on fossil fuel-based electricity. Inadequate integration of life-cycle emissions considerations into industrial environmental governance could shift environmental burdens from vehicle operation to mineral processing and battery production facilities. Similar concerns emerged during the

vehicle operation stage, as electricity supplied through Stasiun Pengisian Kendaraan Listrik Umum (SPKLU), or public electric vehicle charging stations, remained connected to an electricity grid substantially dependent on coal-fired power generation. Consequently, although BEVs eliminated direct tailpipe emissions, their electricity consumption could generate indirect emissions and associated environmental burdens at power generation facilities, potentially affecting communities located near these facilities.

At the downstream stage, uncertainties surrounding end-of-life battery collection, treatment, recycling, and disposal presented additional environmental and public health risks. The findings indicated limitations in formal battery recycling infrastructure and unclear allocation of responsibilities among manufacturers, waste management operators, and regulatory authorities. Although Indonesia has established regulations governing hazardous and toxic waste, known as *Bahan Berbahaya dan Beracun (B3)*, the study identified challenges in establishing and enforcing comprehensive extended producer responsibility (EPR) mechanisms for electric vehicle batteries. Inadequate collection and recycling systems could increase the risk of improper battery handling and hazardous substance releases, particularly where informal waste management activities operated without sufficient technical safeguards or occupational protection. These conditions could generate secondary environmental and social harms, including long-term health risks and increased vulnerability among affected communities.

Overall, the study concluded that Indonesia's accelerated KBLBB development had been driven primarily by technological, economic, and industrial policy objectives, while environmental risk distribution, ecological accountability, and the protection of vulnerable communities had not received equivalent attention. The analysis suggested that existing environmental criminal law policies remained more focused on addressing legally defined violations and pollution incidents than on preventing broader structural environmental harm associated with industrial development. Although Law No. 32 of 2009 concerning Environmental Protection and Management, as amended, provides administrative and criminal enforcement mechanisms, weaknesses in implementation, fragmented regulatory responsibilities, and gaps in life-cycle environmental governance could undermine their effectiveness. Presidential Regulation No. 55 of 2019 and its amendments established the framework for accelerating electric vehicle development but did not independently constitute a comprehensive environmental criminal law regime. From a green criminological perspective, these regulatory limitations could enable environmentally harmful activities to remain legally permissible without adequate ecological accountability, reflecting the concept of "lawful but awful" practices. Therefore, a more comprehensive energy transition policy was needed to integrate preventive environmental regulation, effective enforcement, corporate accountability, meaningful public participation, and environmental justice throughout the electric vehicle life cycle. Without these safeguards, the transition from fossil fuel-powered transportation to electric mobility could reproduce existing patterns of ecological exploitation and disproportionately distribute environmental burdens among vulnerable communities.

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## AUTHOR'S CONTRIBUTION

Robin Kumbarayuda contributed to the formulation of research concepts, the preparation of the theoretical framework of green criminology, the design of research methods, data collection through literature studies, analysis of policy documents, and in-depth interviews, as well as the preparation of an initial draft of the article. Anggi Aulina Harahap contributed to the literature review, environmental harm analysis at each stage of the battery electric vehicle life cycle, environmental criminal policy evaluation, and review and improvement of the manuscript. The two authors contributed to the interpretation of research results, discussion of findings, formulation of conclusions, and approval of the final version of the article for publication.

## GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

The author states that the use of generative artificial intelligence in the preparation of this article, if any, is limited to improving the grammar, sentence structure, and readability of the manuscript. The technology is not used to produce or manipulate research data, engineer interview results, or replace the scientific analysis and interpretation process. All research substances, including literature reviews, policy analysis, discussions, and conclusions, are the full responsibility of the author. The author has examined the entire content of the manuscript and is responsible for the accuracy, originality, and scientific integrity of the article.

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