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Environmental footprint assessment of lithium-ion (Li-ion) batteries in electric scooters: a case study of PT Motor Listrik Indonesia

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ABSTRACT

Indonesia ranks as the world's sixth-largest contributor to CO_2 emissions, with motorcycles alone responsible for 56,788 tons of CO_2 in 2020. While electric motorbikes are considered a cleaner alternative due to their lack of exhaust emissions, their overall environmental impact must be evaluated throughout the entire battery life cycle. This study conducts a gate-to-grave life cycle assessment (LCA) on the lithium-ion (Li-ion) batteries used in MOLINDO electric motorbikes, covering the supplier, production, usage, and disposal stages. The total environmental impact was found to be 920 points (pt), with the usage phase being the largest contributor at 550 pt, followed by production at 185.5 pt, supplier at 179 pt, and disposal at 5.54 pt. Two improvement strategies were explored: reusing external battery cases, which slightly reduced the impact to 918.86 pt, and repurposing second-life batteries, which extended battery use but increased the impact to 998.04 pt due to additional energy requirements. Compared to conventional motorbikes, electric motorbikes still offer a major environmental advantage in the usage phase (550 pt vs. 3,397 pt). These findings suggest that, alongside the shift to electric mobility, targeted actions such as better battery reuse, more efficient recycling, and cleaner electricity sources are essential to fully unlock the environmental benefits of electric motorbikes.

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1. INTRODUCTION

Indonesia is currently undergoing a significant transition in the transportation sector, shifting from a dominance of oil-fueled vehicles to the adoption of electric vehicles (EVs) [1], [2]. Oil-fueled two-wheelers remain central to daily mobility in Indonesia, where motorcycles represent a major transport mode [3]. One of the most common examples of motorized vehicles in Indonesia is motorcycles. However, the operation of motorcycles has negative environmental impacts [4], especially on air quality. Among all the exhaust gases emitted from motorcycle operation, carbon dioxide (CO_2) is the most produced gas [5]. According to the Indonesian Central Bureau of Statistics, in 2020 the total carbon dioxide (CO_2) gas emissions from motorcycle operations reached 56,788 tons of CO_2, as stated [6], [7]. Electric motorcycles have emerged as an alternative that is widely considered more environmentally friendly because they use electrical energy stored in batteries as their primary power source, eliminating direct exhaust emissions. However, the absence of tailpipe emissions does not mean that EVs are entirely impact-free. The battery, particularly lithium-ion

(Li-ion) batteries, serve as the heart of the vehicle and has a relatively short life cycle compared to other components. Throughout its life stages production, distribution, usage, and end-of-life, batteries still generate environmental impacts that must be understood and managed.

To reduce air emissions, electric motorbikes are present as an alternative to environmentally friendly vehicles. This is because electric motorbikes utilize electrical energy contained in batteries as a source of driving energy. Therefore, electric motorcycles are considered environmentally friendly because they do not produce exhaust gases like oil motorcycles. However, even though it does not produce emissions in the form of exhaust gases, further assessment needs to be done regarding other potential environmental impacts that may arise. For this reason, the life cycle assessment (LCA) of every component in an EV, especially the lithium-ion battery, needs to be assessed. LCA is the method applied to a product, process, or service to identify and quantify its environmental impacts, from raw material acquisition and processing, through manufacture and distribution, to reuse, recycling, energy recovery, and disposal in terms of all releases to the environment throughout its life cycle [8], [9]. In this paper, the application of LCA to lithium-ion batteries aims to provide evidence on the most environmentally burdensome components, establish the basis for product design with reduced environmental impact, and put into perspective the relative environmental merit of EVs versus conventional oil-fueled vehicles.

LCA is itself a method used to identify and analyze environmental impacts. The assessment includes the evaluation of environmental impacts resulting from the life cycle of a product, process, or service. The purpose of using this life cycle assessment methodology lies in finding the environmental impacts of products or services, offering a basis for environmentally friendly products, comparing product designs, and upgrading product quality. Conducting an LCA is not only important in understanding the environmental footprint of EV batteries but also in making objective comparisons with conventional vehicles. Such a comparison shows the point of life when EVs generate the most advantages, environmentally, and which stages they have to improve. Therefore, LCA could be used to address policy, industrial decision-making, and informed consumer choices consistent with a cleaner and more sustainable energy transition [10], [11]. This paper addresses the current gaps in quantitative data on life cycle environmental impacts of Li-ion batteries for electric motorcycles in Indonesia, which is highly relevant to the optimization of battery design, operation, and management policies. Based on this, the study will be conducted using a gate-to-grave LCA of the ZT-7220 Li-ion battery in MOLINDO electric motorcycles to provide an overall impact overview, pinpoint the most critical life cycle stages, and put forward practical strategies for improvement. Despite the rapid growth of electric motorcycles, detailed, LCA-based quantification of battery impacts under the Indonesian coal-dominated electricity mix remains inadequate, and their true environmental footprint, particularly during use, is incompletely understood. Previous studies also tend to assume cradle-to-grave or use foreign datasets that do not accurately reflect local transport, assembly, energy usage, or end-of-life practices.

This study addresses existing gaps by focusing on Indonesia-specific operational conditions and domestic manufacturers such as PT Motor Listrik Indonesia. It is a novel and policy-relevant contribution as it provides the first gate-to-grave LCA of the ZT-7220 Li-ion battery in MOLINDO electric motorcycles, based on primary field data. The study includes a detailed comparison of the environmental impacts between electric and conventional motorcycles using harmonized impact categories and evaluates two practical improvement strategies: external case reuse and second-life battery utilization. The research objectives are to: i) quantify the environmental impacts at each stage of the Li-ion battery life cycle, ii) identify the stage with the highest impact, iii) evaluate potential improvement strategies, and iv) compare the environmental impacts of electric and conventional motorcycles using consistent assessment methods.

2. METHOD

2.1. Life cycle assessment (LCA) methodology

LCA is a tool used to analyze the environmental footprint of an industrial process by considering the entire life cycle of a product, typically from cradle to grave. It identifies environmental hotspots—such as emissions, waste, and energy use—so that industries can prioritize improvements in the most impactful areas. The process begins by defining the goal and scope, which includes setting system boundaries (such as direct production vs. the entire value chain) and selecting a functional unit—like kilograms of CO_2-equivalent or liters of water—to quantify inputs and outputs. After the goal and scope are defined, the life cycle inventory (LCI) phase involves collecting and quantifying all inputs (raw materials, water, and energy) and outputs (emissions, waste, and by-products) at each stage of the life cycle. This phase forms the empirical basis for the LCA, but data collection can be challenging and depends on supplier cooperation and detailed process tracking. Therefore, it's recommended to use standardized data sources whenever available [12].

LCIA is carried out after the inventory analysis to convert the inventory data into environmental impacts by applying models to categories such as global warming potential, ozone depletion, and water scarcity. For example, high CO_2 emissions over a product's life cycle increase its contribution to global warming potential. LCIA turns technical data into impact indicators that reflect societal concerns, helping stakeholders understand the broader implications of a product's footprint and prioritize sustainability actions. Common methods like ReCiPe and CML are used, each grouping and weighting impacts differently while focusing on either global or regional scales. This helps guide industries to target interventions in the most significant impact areas [13].

This study performed the LCA method in accordance with ISO 14040 and ISO 14044, using a gate-to-grave scope covering a period from the reception at PT Mobil Listrik Indonesia up to the end of its service life. In these analyses, a ZT-7220 Li-ion battery with a capacity of 20 Ah or 1.48 kWh was employed within MOLINDO electric motorcycles. Four stages were embedded in the analysis: distribution from the supplier, assembling it on the motorcycle, usage until performance degradation, and end-of-life disassembly and component separation. Data collection was carried out through field observations, measurement of electricity use, records of transport distance, and documentation of the assembly/disassembly process, supported by secondary data taken from literature and through the Ecoinvent database in OpenLCA. During the distribution stage, the batteries are transported 24.2 km from the Tanjung Perak Port to the factory by means of a container truck. During production, the battery was installed using electric tools with recorded electricity consumption over an eight-hour shift to produce six units. During its use phase, performing road tests for 60 km daily yielded a total distance traveled of 2,539 km and 53.74 kWh of electricity consumption over a time span of 43 days. At the end of its life, the battery was removed, with an external case weighing 3 kg and a battery module of 7 kg as outputs.

Figure 1 presents the research flow methodology. LCIA was done in OpenLCA under the ReCiPe 2016 impact assessment method. Environmental impacts were assessed for several categories like global warming potential, ozone formation, particulate matter formation, fossil resource scarcity, toxicity, acidification, eutrophication, land use, water consumption, mineral resource scarcity, stratospheric ozone depletion, and ionizing radiation, and then all of them were aggregated into three categories of damage: human health, ecosystem quality, and resources. The results are interpreted, showing the most impactful life cycle stage, analyzing its causes, and making some technical recommendations such as reusing external battery cases and applying second-life batteries to quality control processes.

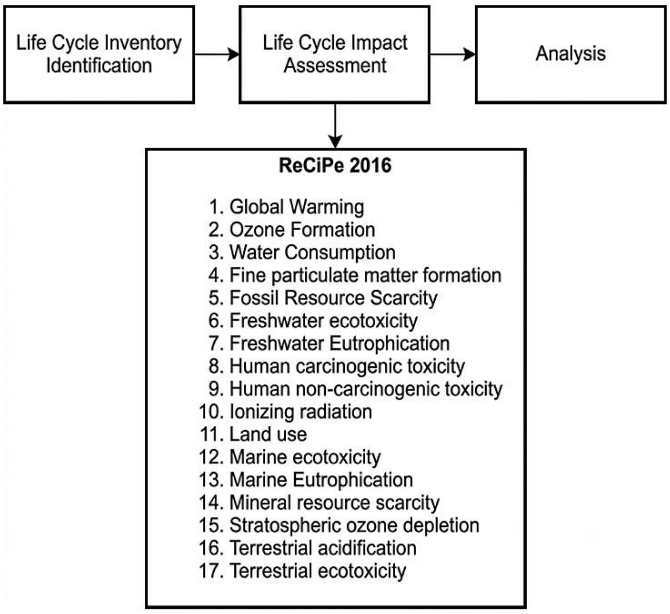

Figure 1. Flow of research

2.2. OpenLCA

OpenLCA is the world-leading software for life cycle assessment, used for analyzing the environmental impacts of products or services, from raw material extraction through final disposal. It allows users to identify hotspots in their products or services, compare different scenarios, and make more environmentally friendly choices. Industry, academia, and policymakers in more than 80 countries are applying OpenLCA for environmental reporting, sustainable product design, and carbon footprint reduction [14]. To this end, OpenLCA is employed in this research as it is the latest version, boasting comprehensive features and databases. In this study, a gate-to-grave LCA is conducted to quantify the environmental impacts of the ZT-7220 Li-ion battery used in MOLINDO electric motorcycles. This approach responds to the fact that there is still a lack of Indonesian battery LCA studies that are representative of real operating conditions and coal-dominated electricity mixes. Unlike many previous works relying mainly on secondary data, this study involves comprehensive primary data from field observations, measurements of electricity consumption, recordings of transport distance, and manual disassembly at PT Motor Listrik Indonesia. Two improvement scenarios are evaluated: reuse of external battery casings and use of second-life batteries for factory quality-control cycles. This methodological design allows the LCA to both assess current environmental performance and propose practical strategies for impact reduction.

3. RESULTS AND DISCUSSION

3.1. Life cycle assessment (LCA) results

Figure 2 shows the lithium-ion battery life cycle and data needed for each stage to perform an environmental impact assessment. A full LCA starts with mining and processing of vital raw materials such as lithium, cobalt, and nickel, which might result in habitat destruction, water pollution, and social issues. Subsequent manufacturing of batteries from these materials is energy-consuming and associated with emissions and waste production. Finally, batteries will be transported to motorcycle assembly plants; distribution logistics contribute to the environmental impact due to fuel consumption and greenhouse gas emissions. During the use of the batteries, their performance dictates the efficiency and, therefore range and energy use of an electric motorcycle, while gradual degradation of capacity eventually leads to replacement. At the end of their life, these batteries may be landfilled or recycled to recover key materials, decreasing the demand for new mining and therefore their overall environmental impact. The six vital stages that complete the life cycle of lithium-ion batteries of electric motorcycles start with manufacturing. Battery manufacturing encompasses raw material extraction, cell production, and pack assembly, which are very energy-intensive and may result in several different emissions. Battery distribution then adds impacts through transport-related fuel use and carbon emissions. In the assembly stage, batteries will be installed on electric motorcycles, involving additional energy use and logistics. In the use phase, batteries power motorcycles, and their efficiency and lifetime strongly influence overall environmental impact. At the end of life, improper battery disposal has the potential to cause toxic emissions and soil contamination, resulting in specific health risks for humans and ecosystems. Finally, recycling can recover valuable materials, reduce raw material demand, and greatly bring down the ecological footprint of lithium-ion batteries.

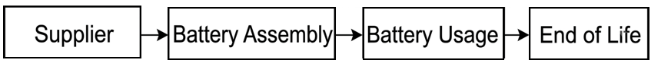

Figure 2. Lithium-ion (Li-ion) battery life cycle

3.1.1. Goal and scope definition

The research targets four life cycle stages for the lithium-ion battery: distribution, assembly in electric motorcycles, use, and disposal. It is a gate-to-grave analysis since the battery will be supplied by an established manufacturer, and raw material extraction and cell manufacturing are outside the scope of direct control. During the distribution stage, fuel use and corresponding emissions due to transport are assessed. The assembly stage includes energy use and the generation of waste when the battery is integrated into the motorcycle. In the use phase, this study takes into consideration how the efficiency of the battery and its degradation influence vehicle performance, energy consumption, and respective emissions during operational life. The last stage is the consideration of end-of-life options that include landfill and recycling options, wherein recovery of materials, such as lithium and cobalt, contributes to decreasing the demand for further raw material extraction. By focusing on these stages, the research points out possible opportunities towards decreasing environmental impacts and furthering sustainability goals.

3.1.2. Life cycle inventory

The life cycle inventory in this study covers four stages of the lithium-ion battery life cycle which consists of distribution, assembly in electric motorbikes, use, and disposal as well as identifying the key environmental outputs such as greenhouse gas emissions, energy consumption, and waste. Transport-related CO_2 emissions and fuel use will be considered in the distribution phase, while in the assembly phase, energy and material usage and the waste from packaging and installation are assessed. During the use phase, attention is focused on battery performance and longevity, including the effects of repeated charging–discharging cycles on the performance and how the electricity mix affects environmental burdens. Advanced battery modeling and state-estimation approaches support more accurate battery management, which can improve operational reliability and help extend battery service life [15]. Moreover, EV charging technologies, charger architectures, and converter configurations influence charging flexibility, efficiency, and system integration [16]. Smart charging strategies can further improve charging flexibility, reduce operational burdens, and support more efficient EV energy management [17]. Additionally, battery efficiency and degradation are analyzed, as these factors influence how much energy is drawn over time and impact the overall environmental footprint. The end-of-life options for final disposal include recycling and landfilling, and the environmental implications of these processes. Recycling prevents the depletion of resources through the recovery of valuable metals such as lithium, cobalt, and nickel, and it reduces the demand for new raw material extraction. The life cycle inventory will give a detailed basis, by identifying and quantifying outputs at each stage, to show where interventions might best reduce environmental impacts throughout the life cycle of a battery. The life cycle inventory identification of the lithium-ion battery life cycle is listed in Table 1.

Table 1. Li-ion battery life cycle inventory identification

Process	Transport/equipment	Input and output	Total output	Assessment
Supplier	Container truck	Li-ion battery	250 pcs	179 pt
		Charger	250 pcs	
		Battery box	10 pcs	
	Forklift truck	Li-ion battery	250 pcs	
		Charger	250 pcs	
		Battery box	10 pcs	
Production	Drill driver	Electric motorcycle	1 pc	185.5 pt
		Electricity	1.43 kWh	
	Fan			
	Lamp			
Usage	Li-ion battery	Mileage	2539 km	550 pt
	Electric	Electricity	53.74 kWh	
Disposal	Drill driver	Li-ion battery	1 pc	5.54 pt
		Electricity	1.40 kWh	
	Lamp			

According to Table 1, in electric motorbikes, the highest impact on the environment is found in the Li-ion battery usage stage, with a value of 550 points. This is due to a distance traveled of 2,539 km, which involves 53.74 kWh of electricity—a huge amount of energy—and, consequently, gradual degradation of the battery performance. Cyclic charging–discharging reduces the capacity, efficiency, and range of the battery, such that beyond this point it cannot serve effectively in an electric motorcycle. This reveals challenges regarding battery longevity and possible strategies that might be focused on energy management system improvements and better chemistry. Improvement in the lifespan of the batteries and reduction in its environmental impact are two critical prerequisites to extending the sustainability and overall effectiveness of electric motorbikes as a low-emission transport solution

3.1.3. Life cycle impact assessment

Table 2 illustrates the environmental impact categories related to the Li-ion battery life cycle. As shown, the highest impacts are associated with the electric motorcycle usage stage and the battery disposal stage, and thus represent the most critical phases in terms of environmental footprint. The evaluated impact categories include global warming, ozone formation, water use, fine particulate matter formation, fossil resource scarcity, freshwater and marine ecotoxicity and eutrophication, human carcinogenic and non-carcinogenic toxicity, ionizing radiation, land use, mineral resource scarcity, stratospheric ozone depletion, and terrestrial acidification and ecotoxicity [18]-[20]. Each of these factors plays a crucial role in determining the overall environmental impact associated with the life cycle of lithium-ion batteries and their usage in electric motorbikes.

Table 2. Life cycle impact assessment battery Li-ion

Impact characterization category	Damage category	Unit	Disposal	Usage
Global warming	Human health	pt	1.5186	153.873
Ozone formation	Human health	pt	0.0227	2.6404
Water consumption	Human health	pt	0.0341	3.4162
Fine particulate matter formation	Human health	pt	3.3752	333.858
Fossil resource scarcity	Resources	pt	0.0370	4.0450
Freshwater ecotoxicity	Ecosystem	pt	0.0001	0.0082
Freshwater eutrophication	Ecosystem	pt	0.0217	2.2865
Human carcinogenic toxicity	Human health	pt	0.1573	12.7658
Human non-carcinogenic toxicity	Human health	pt	0.2466	25.1771
Ionizing radiation	Human health	pt	0.0001	0.0095
Land use	Ecosystem	pt	0.0055	0.6937
Marine ecotoxicity	Ecosystem	pt	0.0001	0.0122
Marine eutrophication	Ecosystem	pt	0.0000	0.0003
Mineral resource scarcity	Resources	pt	0.0047	0.5302
Stratospheric ozone depletion	Human health	pt	0.0004	0.0454
Terrestrial acidification	Ecosystem	pt	0.0924	8.7841
Terrestrial ecotoxicity	Ecosystem	pt	0.0189	1.7984
Total		pt	5.5354	549.944

Furthermore, the overall environmental impacts are organized into three main categories of damage: human health, ecosystems, and resources [21]. Improving lithium-ion battery packaging and thermal management can directly lower life cycle impacts by enhancing efficiency, extending lifespan, and reducing waste [22]. The human health category assesses the risks and hazards to people, especially those associated with air quality and exposure to toxic substances. The ecosystem category refers to how environmental changes impact biodiversity, habitat quality, and ecosystem services. The resources category concerns the sustainability and depletion of natural resources related to the battery's life cycle, including the availability of key raw materials. Organizing impacts into these categories helps stakeholders clearly understand the linkage between electric motorbike use and its environmental consequences; thus, more easily identify targeted mitigations, support sustainable practices, and work on improving environmental policies regarding electric mobility and battery management.

3.1.4. Interpretation

Based on Tables 1 and 2, during the Li-ion battery usage stage, electric motorbikes have the highest environmental impact, given the high consumption of electricity at about 53.74 kWh. Coal-fired steam power plants or PLTU dominate this source of electricity in Indonesia. The combustion of coal emits CO_2, contributing to global warming; it also emits fine particulate matter ($PM_{2.5}$), which is injurious to air quality and lung health, and SO_2 and NOx gases, which can damage the ozone layer [23]. In addition, the construction of PLTU requires a large area of land and water consumption for cooling generators and turbine drives contain SO_2, NOx, and Phosphorus substances. Where these substances, if loaded with water can pollute water (ecotoxicity) and fertilize algae in waters (eutrophication) which can reduce the amount of oxygen dissolved in water. Implementing hybrid energy storage systems that combine batteries with ultra-capacitors, supported by intelligent control strategies, can reduce battery degradation, improve power management, and enhance the overall performance and efficiency of electric vehicles [24]. To find out the comparison of the impact caused by the use of electric motorbikes with the use of petroleum motorbikes, it is necessary to compare the resulting environmental impacts. The comparison of the environmental impact of using electric motorbikes with the use of petroleum motorbikes is contained in Table 3 and Figure 3.

3.2. Comparison of motorcycle usage and electric motorcycle usage

Figure 3 illustrates that the environmental impact of electric motorbikes is significantly lower than that of conventional motorbikes, with impact values of 550 points (pt) and 3,397 points (pt), respectively, as also summarized in Table 3. These findings confirm the huge potential of electric motorbikes to reduce the environmental burdens on road transport. The dominance of the usage phase in the overall impact of the battery underlines the necessity of energy efficiency measures, particularly in countries where electricity is still mainly produced from coal. As presented in Figure 4, these may involve improving the energy density of the batteries, optimizing thermal management to limit energy losses, and adopting modular designs allowing components like external casings to be reused or recycled. In this way, the battery's lifetime can be extended, the replacement rate and corresponding demand for primary materials can be lowered, thereby reducing costs and environmental impacts.

Table 3. Comparison impact category

Impact characterization category	Damage category	Unit	Motor cycle	Disposal	Electric motorcycle
Global warming	Human health	pt	1096.879	1.5186	153.873
Stratospheric ozone depletion	Human health	pt	0.889	0.0004	0.0454
Ionizing radiation	Human health	pt	0.448	0.0001	0.0095
Ozone formation, human health	Human health	pt	26.889	0.0227	2.6404
Fine particulate matter formation	Resources	pt	1707.639	3.3752	333.858
Terrestrial acidification	Ecosystem	pt	59.360	0.0924	8.7841
Freshwater eutrophication	Ecosystem	pt	0.1578	0.0217	2.2865
Marine eutrophication	Human health	pt	0.0005	0	0.0003
Terrestrial ecotoxicity	Human health	pt	0.719	0.0189	1.7984
Freshwater ecotoxicity	Human health	pt	0.0495	0.0001	0.0082
Marine ecotoxicity	Ecosystem	pt	0.0145	0.0001	0.0082
Human carcinogenic toxicity	Ecosystem	pt	5.3603	0.1573	12.7658
Human non-carcinogenic toxicity	Ecosystem	pt	23.807	0.2466	25.1771
Land use	Resources	pt	0.782	0.0055	0.6937
Mineral resource scarcity	Human health	pt	0.0066	0.0047	0.5302
Fossil resource scarcity	Ecosystem	pt	448.298	0.037	4.045
Water consumption	Ecosystem	pt	26.068	0.0341	3.4162
Total		pt	3397.36	5.5354	549.94

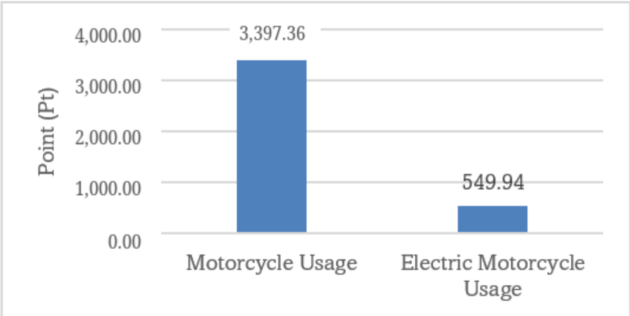

Figure 3. Comparison of the environmental impact of electric motorcycles and oil-fueled motorcycles

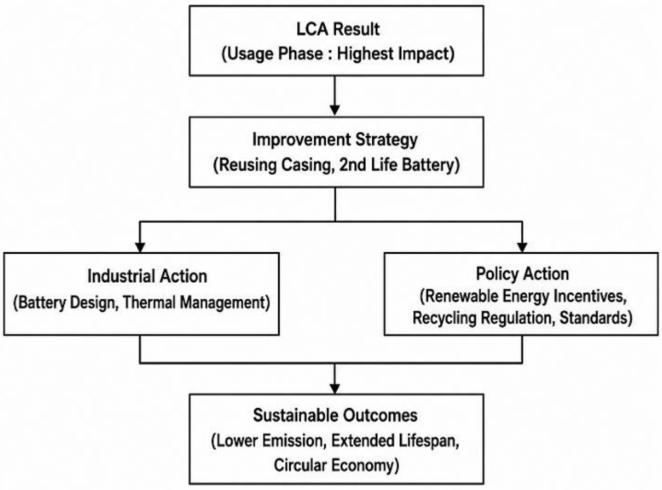

Figure 4. Framework from LCA results to sustainability

From a policy perspective, integrating clean energy is essential to maximizing the environmental benefits of electric mobility. Incentives for renewable-based EV charging, subsidies for battery recycling infrastructure, regulations on standardized battery designs, and mandatory collection and recycling quotas can enhance material recovery, reduce dependence on environmentally intensive mining, and promote a circular economy. By aligning innovation with such policies, Indonesia can reduce the life cycle impacts of electric motorbike batteries, contribute to national climate goals, and strengthen its role as a regional leader in sustainable electric mobility.

This study reveals that, for the ZT-7220 Li-ion battery, the usage stage has the highest environmental impact compared to distribution, assembly, and disposal, based on real-world conditions in Indonesia. These quantified impacts provide a clear foundation for evaluating improvement options and differ from many previous LCA studies, which often highlight the production or manufacturing phase as the primary environmental hotspot due to the intense material extraction and cell fabrication involved [25]. Review-based analyses further emphasize that many LCA studies rely heavily on secondary datasets and often lack region-specific operational parameters, resulting in limited representation of local conditions [26]. In addition, comparative LCAs between electric and conventional motorcycles show that the environmental advantage of electric vehicles typically depends on the cleanliness of the electricity grid used for charging [14].

In contrast to most previous studies, this research identifies the usage phase as the dominant contributor to total environmental impact, mainly because Indonesia's coal-based electricity mix increases upstream emissions from battery charging. These results show how regional energy systems can shift the life-cycle hotspot of electric vehicle batteries. By integrating primary field data, such as actual transport distances, assembly activities, operational electricity use, and end-of-life disassembly, and by evaluating two improvement scenarios, external case reuse and second-life battery application, the study provides empirical, context-specific insights and practical options for impact reduction and highlights potential trade-offs, thereby enriching existing LCA literature on electric vehicle batteries.

4. CONCLUSION

LCA results indicate that while electric motorbikes do not have direct exhaust emissions and their overall environmental impact is smaller compared with conventional motorbikes, their Li-ion batteries still produce significant impacts, attaining 920 pt for the MOLINDO battery system, with domination by its use phase at 550 pt due to electricity based on fossil fuels. Waste reduction and prolonged utility possibilities by reusing external battery casings and utilizing second-life batteries should be completed with efficient management, increasing recycling rates, and offering cleaner manufacturing and low-carbon electricity if full environmental benefits are to be realized. The completeness of Indonesian primary data in this study provides a more representative insight into Li-ion battery performance in local conditions. In this case, different from most studies on batteries internationally, it is determined that the usage phase is a major driver of impacts, addressing national electricity mix importance. Such findings could help fill the gap in studies related to contextual battery LCA and provide scientific evidence for the optimization of battery design, charging strategy, and its management at the end of life.

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AUTHOR CONTRIBUTIONS STATEMENT

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Dwi Heru Siswantoro					✓	✓			✓	✓	✓	✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [SI], upon reasonable request.

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