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Electric Car Battery Waste in Indonesia: Projections and Management Policies

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Abstract – Global trends in electric vehicle adoption have been increasing significantly in recent years. In Indonesia, the government has issued various policies to encourage the use of electric cars. However, anticipation of the environmental impact of this program has not yet received serious attention. Current regulations regarding battery waste management still refer to existing regulations governing hazardous and toxic waste. This study aims to forecast the potential of battery waste from electric cars in the future and provide policy recommendations to establish a sustainable electric car program. The methods of analysis employed include material flow analysis and policy content analysis. Based on three scenarios (low, medium, and high adoption scenarios), the analysis results show a significant increase in battery waste in all scenarios from 2025 to 2040. The increase in active materials, aluminum, and copper waste could exceed 50 times during this period. Electrolyte, plastic, and steel waste also increase substantially, with growth reaching 30–50 times. Although relatively small in volume, rare earth metals are projected to rise 19 times. By 2040, the potential of battery waste is estimated to reach 1,998,911 tons in a low adoption scenario, 2,600,540 tons in a medium adoption scenario, and 3,170,517 tons in a high adoption scenario. The result of policy content analysis of the electric vehicle regulations issued by the Indonesian government since 2019 demonstrates that efforts to enhance electric vehicle adoption will become the main focus for the government in the coming years. A thematic mapping of policies related to 20 electric vehicle regulations published during this period reveals that only three regulations address environmental issues. This study indicates the need for policy improvements by formulating specific derivative regulations that govern electric car battery waste management.

Keywords: electric cars, battery, waste management, policy, environment.

Introduction

The global trend in electric vehicles (EVs) has increased in recent periods, as indicated by the increase in electric vehicle use from only about 17 thousand units in 2010 to 7.2 million units in 2019 (IEA, 2020). China was leading with 47% of the global EV population in 2019 (IEA, 2020) and is expected to continue growing to more than 50% in 2025. It is along with the fact that China's EV sales are higher than the world (Wu and Chen, 2022).

Ling *et al.*, (2021) investigated the basic factors that drive potential buyers to purchase EVs in China. In another area, (Sobiech-Grabka *et al.*, 2022) developed a robust forecasting model using the Advanced Machine Learning method to identify the main factors in predicting consumer behavior regarding the willingness to purchase electric vehicles. From a policy standpoint, (Li *et al.,* 2020) examined the impact of a portfolio of policies (production, usage, and recycling policies) on adopting new energy vehicles (NEVs) from a product life cycle perspective. Policy understanding, consumers' purchasing behavior, and production and recycling policies are some indicators used in this research.

Global studies about EVs suggest positive impacts on the environment, such as improving air quality and reducing greenhouse gas (GHG) emissions from the transportation sector in varying levels (Chen *et al.*, 2021; Fuentes and González, 2021). For example, (Fuentes and González, 2021) indicate a slight reduction of GHG emissions obtained from the EV program for taxis in Mexico City, and the adoption of renewable energy sources

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is needed to achieve greater reduction and take full advantage of the benefits of EVs. A study by Shetty *et al.,* (2020) stated that EVs are one of the short-term practical solutions in-vehicle technology that can reduce GHG emissions and dependency on fossil fuels. While (Ghasri *et al.*, 2019) measured the perceived advantage of using EVs rather than internal combustion engine vehicles (ICEVs).

Although the massive use of EVs can reduce the emissions from the vehicle tailpipes, the increasing of EV production activities and the increasing emissions from the power plants to fulfill the EVs demand can eliminate some or all of the emission reductions obtained from the EVs transformation. So, the policies to enlarge EVs adoption must be accompanied by initiatives in green manufacturing and green power generation (Chen *et al.*, 2021). Moreover, (De Wolf *et al.*, 2022) emphasized the importance of optimization in determining the quantity and location of charging stations to provide smoother traffic for other vehicles and reduce CO_2 emissions by up to 28%, even though it is only from the 10% market share of EVs.

Despite its various advantages, it is undeniable that EVs also have negative impacts on the environment, such as battery waste, which can be categorized as material-intensive and hazardous at their end of life (IEA, 2020). EVs can be a main concern and challenge for waste management at the end of their life if not managed properly (Harper *et al.*, 2019; Raugei and Winfield, 2019). (Preeti and Sayali, 2021) state that battery waste from EVs is one of the e-waste types that is predicted to increase significantly in the future. Using batteries in EVs that have a life limit can pose a new threat to the environment. Therefore, some strategies and policies are needed to anticipate this potential threat.

Referring to the policies that have been widely launched by the Indonesian government recently, it seems that the focus to be achieved by the government is how to make the EV program in Indonesia develop massively in the next 1 to 5 years. The government issued various stimuli through the Ministry of Industry, the Ministry of Energy and Mineral Resources, the Ministry of Transportation, the Ministry of Home Affairs, and the Ministry of Finance. The government has pursued various policies, such as preparing regulations, ease of licensing, providing fiscal incentives, supporting technology development, preparing infrastructure, and socialization to the public. However, there are still very few policies regarding environmental impact management due to the future use of EVs. This study aims to forecast the generation of battery waste due to the increasing number of electric cars, as well as to evaluate the existing policies and provide recommendations to create a sustainable EV program.

Materials and Methods

This study refers to the model developed by (Jiang *et al.,* 2021) in estimating the weight of battery waste that reaches the end of life (EOL) stage and various constituent materials. Estimates are made until 2040. The calculation of the amount of electric car battery waste that reaches the EOL stage [$B(t)$] is carried out by considering the number of batteries accumulated at the use stage [$E_i(t\text{-}k)$] and the percentage of batteries entering the EOL stage [$P_i(t, k)$], as described in the equation (1).

$$B(t) = \sum_{i} \sum_{k} E_i(t-k) \times P_i(t,k) \tag{1}$$

Where $B(t)$ = number of electric car batteries entering the EOL stage in year t; i = battery type, k = battery life; $E_i(t\text{-}k)$ = number of type i electric car batteries entering the usage stage in year $t\text{-}k$; $P_i(t, k)$ = percentage of type i electric car batteries sold in year k that reach the EOL in year t.

Five types of batteries that are mostly used in Indonesia recently and in the future were calculated in this study: nickel-metal hydride (NiMH), lithium-iron-phosphate (LFP), lithium nickel manganese cobalt oxide (NMC), lithium manganese oxide (LMO), and nickel cobalt aluminum oxide (NCA). Lead acid batteries used by many Hybrid Electric Vehicles (HEVs) in 2017 and 2018 are calculated based on historical data but are assumed not to be used after 2018.

The battery life was determined based on the battery warranty period (Jiang *et al.*, 2021). Referring to various information, the current EV battery warranty ranges from 6 to 8 years and will be longer with technological improvement in the future. Referring to China's technology roadmap, it was found that the battery life will increase to 10, 12, and 15 years in 2020, 2025, and 2030 (Jiang *et al.*, 2021). That study also stated that the EV

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battery life in America will gradually increase from 5.5 years in 2010 to 12.5 years in 2035 on average. This study used a relatively conservative battery life assumption: 8 years for 2017-2030, 10 years for 2031-2035, and 12 years for 2036-2040.

The number of batteries at the use stage [$E_i(t)$] is obtained by summing the batteries identified from new car sales (first use) [$S_i(t)$] and reused or second-use batteries [$N_i(t)$], as depicted in equation (2).

$$E_i(t) = S_i(t) + N_i(t) \tag{2}$$

The calculation of the number of reused batteries (reuse or second use) [$N_i(t)$] could be done based on equation (3). However, in terms of the undeveloped technology of reusing EV batteries in Indonesia, no battery remanufacturing process has been considered in this study. Therefore, the value of θ in equation (3) is set to be 0, or it is assumed that there are no batteries at the use stage originating from the reuse process [$N_i(t) = 0$].

$$N_i(t) = \theta \sum_k S_i(t-k) \times P_i(t,k) \tag{3}$$

The percentage of EV batteries reaching the EOL stage [$P(t)$] is calculated using the Weibull distribution function with 2 parameters: the shape parameter (a) and the scale parameter (β) (Jiang *et al.*, 2021; Asokan *et al.*, 2023), as in equation (4).

$$P(t) = 1 - e^{\left(-\frac{t}{\beta}\right)^{\alpha}} \tag{4}$$

Where P(t) = percentage of EV batteries that reach EOL in year t, e = Euler's number (2.71828), a = shape parameter (determined based on previous research, which is 3.5), β = scale parameter (determined based on battery life).

Battery life is equated to the average battery warranty period provided by EV manufacturers (Ai *et al.*, 2019; Jiang *et al.*, 2021). Referring to the average battery warranty period of EVs in Indonesia, this study determined the battery life of EVs to be 8 years for EVs that are sold until 2030, 10 years for EVs that are sold in 2031-2035, and 12 years for EVs that are sold in 2036-2040.

The calculation of the total weight of batteries that reach the EOL stage [$W(t)$] is obtained by multiplying the amount of EV battery waste that reaches the EOL stage by the weight of each EV battery according to its type [$\omega_i(t-k)$], as described in equation (5).

$$W(t) = \sum_i \sum_k E_i(t-k) \times P_i(t,k) \times \omega_i(t-k) \tag{5}$$

Battery weight is a function of the battery energy density (in Wh/kg) and capacity (in kWh). The battery capacity value used in this study was simulated by considering the battery capacity value of each type of EV sold in Indonesia during 2022-2023 and various scientific articles. The battery capacity value is set for three types of EVs (Hybrid Electric Vehicle/HEV, Plug-in Hybrid Electric Vehicle/PHEV, and Battery Electric Vehicle/BEV) and is formulated to increase gradually with the assumption of increased technology and battery capacity of EVs in the future. The energy density value for each type of electric car battery used in this study refers to the average value of the battery energy density from various scientific articles.

Calculation of weight for various types of materials contained in electric car batteries that reach the EOL stage [$M_j(t)$], as described in equation (6). The seven main materials considered in this study consist of active materials, electrolytes, aluminum, copper, plastic, steel, and rare earth metals. Apart from these seven materials, they are accumulated as other materials.

$$M_j(t) = \sum_i \sum_k E_i(t-k) \times P_i(t,k) \times \omega_i(t-k) \times \eta_{i,j}(t-k) \tag{6}$$

Where $M_j(t)$ = weight of material j contained in the EV battery that reaches the EOL stage in year t, $\eta_{i,j}(t-k)$ = composition of material j contained in the EV battery in year t-k.

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Results

Historical data on EV sales in 2017-2023 shows exponential growth. This is due to the surge in EV sales throughout 2022 and 2023 (Figure 1). The presence of compact BEVs at an affordable price in 2022 was welcomed by Indonesian consumers who were previously only offered EV products at high prices. In 2023, the marketing of the HEV from an automotive brand that is very trusted in Indonesia resulted in a surge in sales of HEV types up to 5 times from the previous year. Sales of the Toyota Kijang Innova Zenix (HEV), which in 2023 reached 27,705 units, exceeded the total sales of EVs throughout 2022. This finding strengthens the research results of (Jiang *et al.,* 2021) and (Gunawan *et al.,* 2022) regarding the influence of price and brand image on public interest in buying EVs.

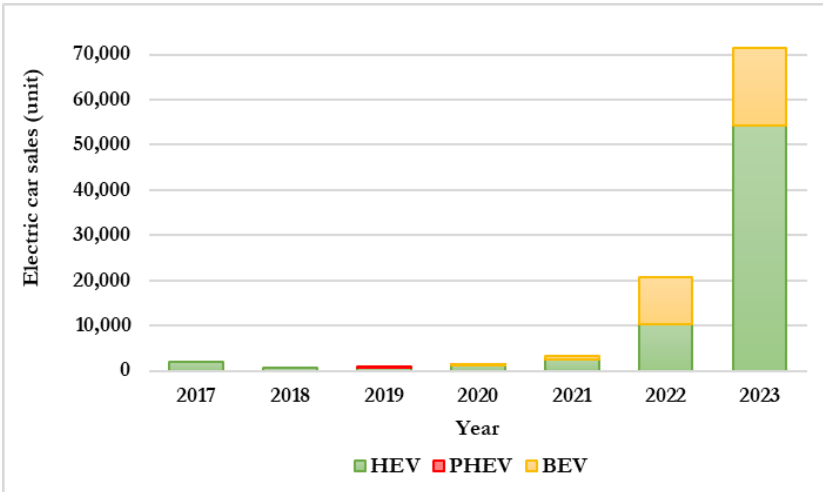

Figure 1. EV sales per year (Gaikindo, 2024)

The projection of EV sales in 2025, 2030, 2035, and 2040 is estimated on average based on sales projection data collected from various sources such as government work plans, research institute reports, and scientific articles (Table 1).

Table 1. Projection of electric car sales in Indonesia from various references

References	Electric Car Sales Projection (unit)			
	2025	2030	2035	2040
Djubaedah *et al.,* (2023)	38,005 185,100 334,300	543,119 1,100,000 2,100,000	1,281,560 3,350,000 5,850,000	2,020,000 5,600,000 9,600,000
Institute for Essential Services Reform/IESR (2023)		2,000,000		
Ministry of Energi and Mineral Resources (2022, 2024)	239,935	2,197,780 2,000,000		
Ministry of Industry (2020, 2022)	1,690,000 400,000	2,100,000 600,000	2,500,000 1,000,000	
Kurniawan *et al.*, (2020)				283,000 525,000
PT Perusahaan Listrik Negara/PLN (2021)	16,000	65,600		
Setiawan *et al.,* (2022)	5,000	15,000	38,000	

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Projections of EV sales in the future are often influenced by various factors, such as incentive policies, technological developments, and consumer interest in environmentally friendly vehicles. In this study, projections of electric car sales were calculated by three scenarios: (1) Medium Adoption Scenario (MAS), using the average value of sales projection data from various references; (2) Low Adoption Scenario (LAS), obtained by subtracting 20% from the MAS value; and (3) High Adoption Scenario (HAS), obtained by adding 20% to the MAS value (Figure 2). Using these three scenarios, the estimated number of EVs in Indonesia in 2040 will cumulatively reach 24,242,108 units in LAS; 30,268,691 units in MAS; and 36,295,273 units in HAS.

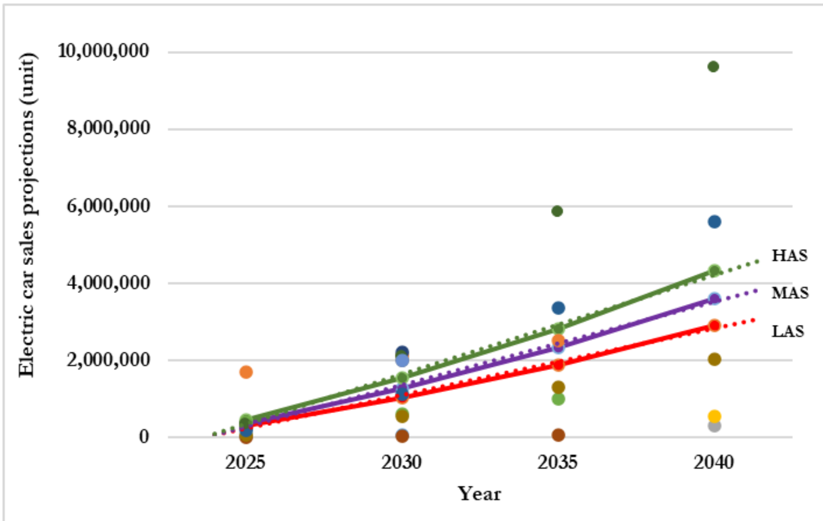
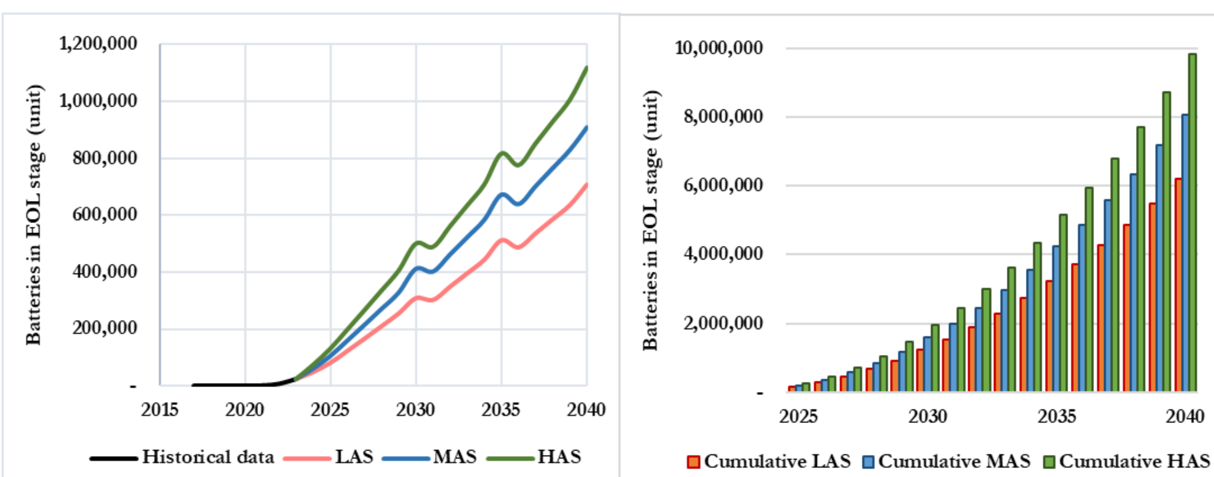


Figure 2. Projection of electric car sales in Indonesia 2025-2040 (analyzed by authors, 2024)

Projections of Battery Waste

The calculation results show that the number of EV batteries reaching the EOL stage in 2025 is 81,844 units in LAS, 105,848 units in MAS, and 131,655 units in HAS. This number continues to increase every year until it reaches 708,438 units (LAS), 908,352 units (MAS), and 1,117,387 units (HAS) in 2040. Decreasing amounts only occur in 2031 and 2036 due to changes in the battery life assumption, which increases from 8 years to 10 and 12 years. Cumulatively, the number of EV batteries that reach the EOL stage in 2040 is 6,197,753 units (SAR), 8,076,463 units (SAM), and 9,837,426 units (SAT). This number is about 40 times higher than the cumulative number in 2025 (Figure 3).



(a) (b)

Figure 3. Amount of electric car batteries at the EOL stage based on 3 scenarios:
(a) annual amount; (b) cumulative amount (analyzed by authors, 2024)

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The total accumulated battery weight for each year [W(t)] was calculated on six types of batteries analyzed in this study: lead acid battery, NiMH, LFP, LMO, NCA, and NMC. For this purpose, the weight per EV battery for each type of battery ($\omega i(t-k)$) was calculated by dividing the battery capacity value by the battery energy density value.

Based on the battery capacity values of each type of EV marketed in Indonesia during 2022-2023, it was obtained that the average battery capacity value was 1,228 Wh for HEV, 14,675 Wh for PHEV, and 42,011 Wh for BEV. This value is within the range of the battery capacity values for EVs in various studies, as summarized in Table 2. The study conducted by (Jiang *et al.,* 2021) used 1,300 Wh for NiMH capacity value and 1,500 Wh for lithium battery capacity value used in HEV.

Table 2. Electric car battery capacity from various references

References	**Battery Capacity for PHEV and BEV (Wh)**			
	LFP	**LMO**	**NCA**	**NMC**
Salgado *et al.,* (2021)	65,000	14,500	80,500	35,800
	106,000	14,500	102,400	95,000
Verma *et al.,* (2021)	20,000	20,000	-	-
	24,000	24,000	-	-
Liu *et al.*, (2022)	19,000	16,000	75,000	24,000
	19,000	42,000	100,000	84,000
Khan *et al.,* (2023)	65,000	14,500	80,500	35,800
	106,000	14,500	102,400	95,000
Average (Wh)	**52,250**	**21,750**	**89,475**	**59,700**

Based on the references above, this study uses the value of the electric car battery capacity as in Table 3 to estimate the total weight of EV battery waste accumulated in the future. This battery capacity value is formulated to increase gradually based on the assumption that there will be improvements in technology and battery capacity in the future.

Table 3. The value of the electric car battery capacity used in the study

Year	**Battery Capacity (Wh)**		
	HEV	**PHEV**	**BEV**
2017-2024	1,200	14,000	40,000
2025-2029	1,500	16,000	50,000
2030-2034	1,700	18,000	60,000
2035-2039	1,900	20,000	80,000
2040	2,000	25,000	100,000

Based on the battery capacity and energy density above, and by considering the number of each type of battery reaching the EOL stage, the estimated weight of each type of battery entering the EOL stage per year can be seen in Figure 4.

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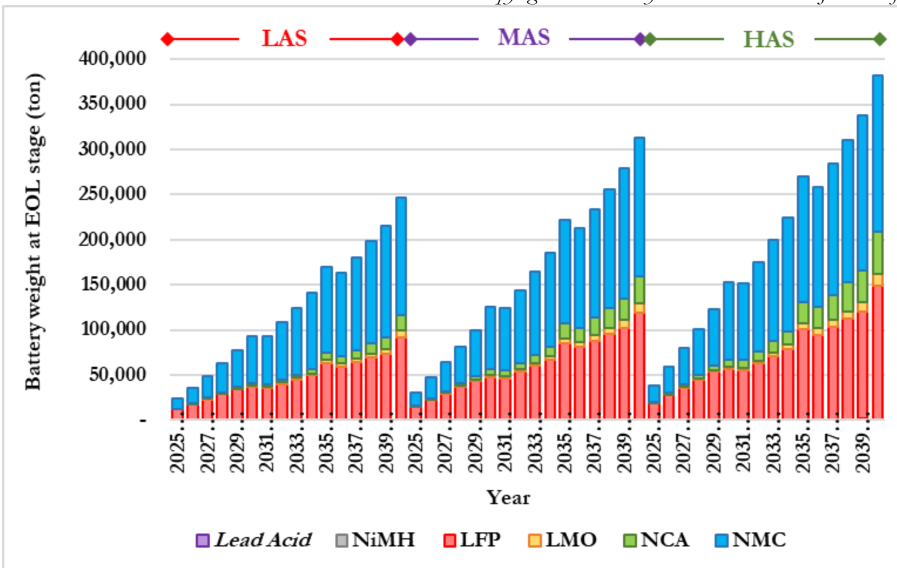


Figure 4. Weight of electric car batteries at EOL stage per year based on 3 scenarios (analyzed by authors, 2024)

The accumulated weight of batteries reaching the EOL stage before 2025 only reached less than 25 thousand tons in all three EV adoption scenarios. However, by the end of 2035, this figure jumped to 996,636 tons for LAS, 1,307,011 tons for MAS, and 1,598,495 tons for HAS. Without any policy intervention in EV battery waste management, this number will continue to increase to 2 million to 3.1 million tons by 2040 (Figure 5).

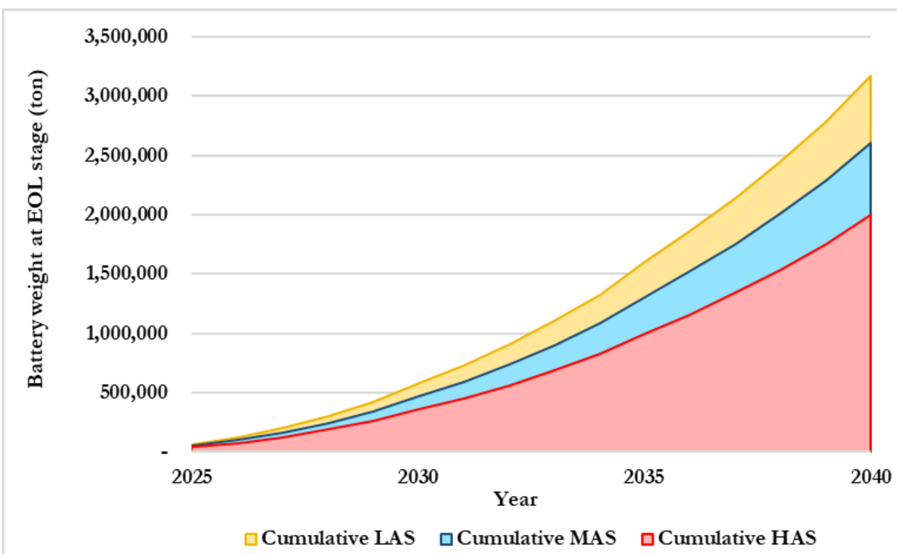


Figure 5. The cumulative weight of electric car batteries at the EOL stage based on 3 scenarios (analyzed by authors, 2024)

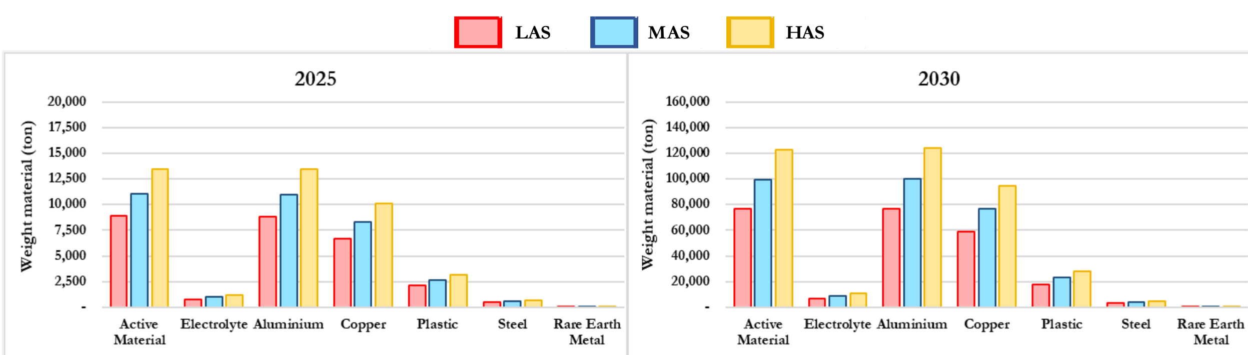
Referring to (Jiang *et al.,* 2021), the composition of EV battery materials can generally be classified into several parts, including active materials, graphite/carbon black, binder, aluminum, copper, electrolyte, organic solvent, plastic, steel, electronic components, and other materials. The NiMH type battery widely used in HEVs in Indonesia does not contain graphite/carbon black, binder, aluminum, copper, electrolyte, organic solvent, and electronic components but has a rare earth material content of 6.3%. Therefore, the composition of the battery material considered in this study only consists of active materials, electrolytes, aluminum, copper, plastic, steel, and rare earth metals. Other than that, the material is classified as other materials.

The material composition refers to lead-acid batteries that were only used in 2017-2018 (Linden and Reddy, 2002). For this type of battery, the material composition calculated in this study is only the active material and electrolyte, which are 36% and 27.5%. The remaining 36.5% (consisting of grids (21.5%), top lead (4.7%), and containers, caps, vent plugs, and separators (10.3%)) are not calculated further because they are not suitable for other types of batteries. For more detail, the material composition for each type of EV battery used in this study can be seen in Table 6.

Table 4. The material composition of electric car batteries considered in the study (Linden and Reddy, 2002; Jiang *et al.*, 2021)

Material Composition	Percentage of Each Battery Type (%)					
	Lead Acid	**NiMH**	**LFP**	**LMO**	**NCA**	**NMC**
Active Material	36	31	22,3	30,7	21,6	19,9
Electrolyte	27,5		2,3	1,7	1,6	1,5
Aluminium		0,5	21,65	22,7	24,9	21,3
Copper		3,9	15	11,6	12,1	18,2
Plastic		22,5	5,4	1,7	1,7	4,5
Steel		35,7	1,15	0,6	0,6	
Rare Earth Metal		6,3				
Others	36,5	0,1	32,2	31	37,5	34,6

The weight of the battery material is calculated by multiplying the EOL battery weight by the percentage of materials in Table 6. This calculation is performed for each material composition in all types of batteries from the three types of EVs considered in this study. The results of this material weight calculation are assumed to have the potential for future battery waste (Figure 6).



(a) (b)

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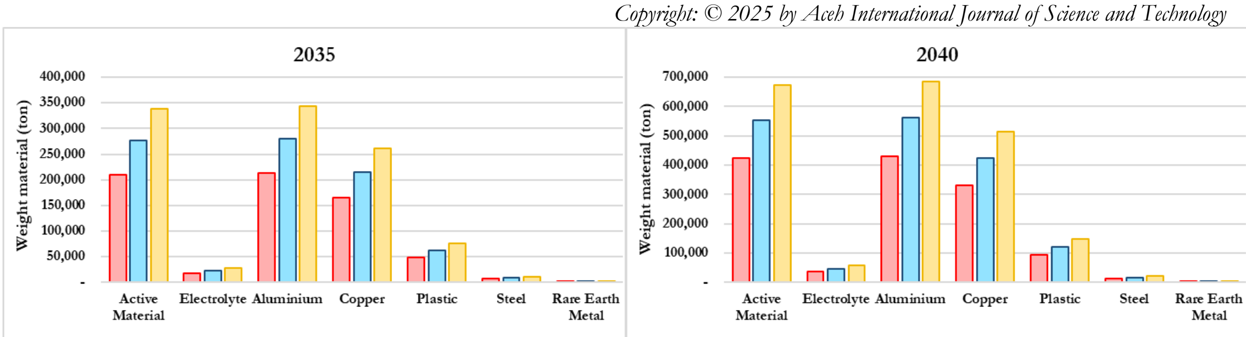

(c) (d)

Figure 6. Projection of battery waste materials in 3 scenarios: (a) 2025; (b) 2030; (c) 2035; (d) 2040 (analyzed by authors, 2024)

In 2025, with a low adoption scenario, the total weight of active materials is estimated to reach 8,912 tons, aluminum 8,814 tons, and copper 6,645 tons. This value increases slightly in medium and high adoption scenarios, with the total weight of each material being less than 15 thousand tons. In 2030, the weight of active materials will reach 76,397 tons, aluminum 76,777 tons, and copper 58,971 tons in LAS. In MAS, the weight of active materials is 99,515 tons, aluminum is 100,154 tons, and copper is 76,624 tons. In HAS, the value is much higher; active materials reach 122,919 tons, aluminum 123,919 tons, and copper reaches 94,626 tons. This value continues to increase in 2035 and 2040. In 2040, the projection results with HAS show that the accumulated weight of active materials will reach 674,052 tons, aluminum 686,210 tons, and copper 515,651 tons.

Battery Waste Management Policy

The Indonesian government's goal to increase the adoption of EVs is emphasized by the issuance of Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery Electric Motor Vehicle Program for Road Transportation. Since 2019, at least 15 regulations have been issued by the central government and 2 regulations issued by the DKI Jakarta Provincial Government to provide a legal basis to encourage EV usage and create an EV ecosystem in Indonesia. During this period, only 3 EV regulations related to environmental issues existed. Policy content analysis was conducted on the 20 regulations to identify the objectives and key points of the policies.

In general, the EV policies implemented in Indonesia aim to encourage the adoption of EVs as environmentally friendly vehicles to reduce emissions and dependence on fossil fuels. These regulations demonstrate Indonesia's commitment to encouraging the use of EVs as part of the national strategy to achieve emission reduction targets in the transportation sector. The result analysis of those 20 regulations strengthens the finding that efforts to increase EV adoption are still the government's main focus for the next few years. The mapping of policy themes shows that there are only three regulations with an environmental theme (Figure 7).

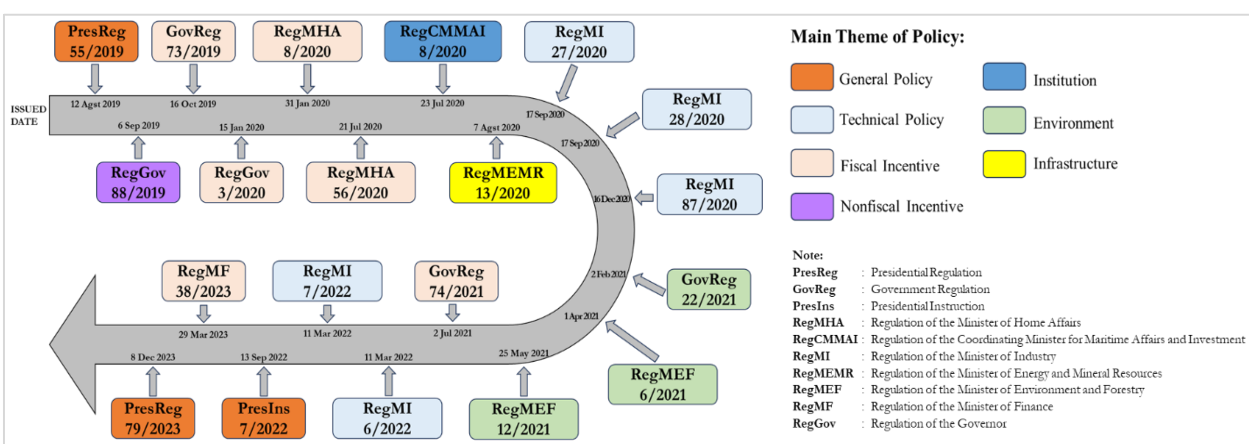

Figure 7. Mapping of policy main themes regarding EV in Indonesia (analyzed by authors, 2024)

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Although Presidential Regulation Number 55 of 2019 has provided a policy basis regarding the main provisions for handling battery waste management from EVs (Articles 32 and 33), as well as providing incentives to companies that manage battery waste (Article 17), until now, there have been no derivative regulations issued in response to these provisions. Regulations related to the environment and management of EV battery waste can only be linked to several existing regulations, such as Law Number 32 of 2009 concerning Environmental Protection and Management (which has been last amended by Law Number 6 of 2023), Government Regulation Number 22 of 2021 concerning Implementation of Environmental Protection and Management, Regulation of the Minister of Environment and Forestry Number 6 of 2021 concerning Procedures and Requirements for Hazardous and Toxic Materials Waste Management, and Regulation of the Minister of Environment and Forestry Number 12 of 2021 concerning Emission Quality Standards for Lithium Battery Recycling. Therefore, it is necessary to propose policy improvements to create a more sustainable EV program.

Discussion

The results of the material flow analysis show the high potential for battery waste due to the increasing use of EVs in the future. This battery waste has the potential to pollute the environment if not managed properly (Kang *et al.*, 2013; Nauri *et al.*, 2024). In addition, Indonesia faces significant challenges related to limited nickel reserves, which are one of the primary raw materials used to produce EV batteries. Nickel is included in non-renewable resources, so Indonesia cannot depend on this commodity for long. Therefore, it is essential to develop a strategy that allows the recycling and reutilization of batteries that have reached the EOL stage to extend the usage of this non-renewable material.

When the EV batteries reach the EOL stage, several options can be applied to manage it (Jose *et al.*, 2024). One option is disposal, usually done when the battery is badly damaged or destroyed to the point where it cannot be repaired and is unsuitable for reuse. Another option is recycling, which is recovering the metal material contained in the battery to reuse it for other applications.

Recycling and implementing the circular economy concept can be proposed as a solution to reduce battery waste and restore non-renewable resources. This concept focuses on recycling, recovery, and reuse (reutilization) of battery materials for new applications (Fotouhi *et al.*, 2016; Sun *et al.*, 2021). Electric car battery recycling can be done through various methods, such as pyrometallurgy and hydrometallurgy (Jose *et al.*, 2024). The recycling process can extract valuable metals such as nickel, cobalt, and lithium from used batteries (Dunn *et al.*, 2022).

EV batteries that have reached the EOL stage can also be reused in energy storage applications, such as the Battery Energy Storage System (BESS), which stores electrical energy from renewable energy sources such as solar and wind energy (Guenther *et al.*, 2024). In this concept, batteries are integrated into a modular energy storage system connected to the electricity grid. This system stores excess renewable energy and provides backup power when peak electricity demand occurs. This concept can not only reduce waste but also increase the stability of the electricity grid and support the integration of renewable energy. EV batteries with decreased capacity and performance can still be used in other applications that require lower energy levels or integrated into other energy storage systems. This is a way to extend the battery life. For example, implementation by B2U Storage Company in the United States has succeeded in reusing old batteries to store electrical energy from solar panels for more than five years before being recycled into new batteries (Jose *et al.*, 2024).

Applying the recycling and reutilization concept and reducing waste can also optimize the utilization of non-renewable resources whose availability is decreasing. Therefore, the EV policy should be accompanied by a policy to encourage the development of the battery waste recycling industry and derivative industries that can reuse (reutilize) EV batteries. This practice is a way to implement the circular economy concept in the EV ecosystem.

Conclusion

The study showed that the potency of battery waste resulting from the increasing EV usage is projected to be very high in the three adoption scenarios. This projection demands serious attention from the government to prevent negative environmental impacts. On the other hand, the EV policy issued by the Indonesian government still has limitations, such as the lack of regulations regarding the management of EV battery waste.

The EV policy implemented by the Indonesian government should be sustainable. This policy not only provides positive impacts in reducing carbon emissions and dependence on fossil fuels, but it must also be able to prevent negative impacts on the environment, such as pollution due to poor management of EV battery waste.

Therefore, it is recommended that the government prepare regulations that specifically regulate the flow of EV battery waste immediately. The government is also expected to be able to formulate policies to accelerate the development of the recycling and battery waste management industry, as well as encourage the development of derivative industries that can utilize battery waste materials.

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