Electric Vehicle Battery End-Of-Life Management in Malaysia

LANDSCAPE REPORT

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Cover image:View of bustling traffic on the Penang Bridge against a mountain backdrop in Malaysia.
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gaia

Global Alliance for Incinerator Alternatives (GAIA) is a global network of more than 800 grassroots groups, networks, NGOs, and individuals. We envision a just, Zero Waste world built on respect for ecological limits and community rights, where people are free from the burden of toxic pollution, and resources are sustainably conserved, not burned or dumped. We work to catalyze a global shift towards ecological and environmental justice by strengthening grassroots social movements that advance solutions to waste and pollution.

PULAU PINANG

The Consumers' Association of Penang (CAP) is a grassroots non-profit, civil society organization based in Malaysia; established in 1969 to promote critical awareness and action among people in order to uphold consumer rights and interests. CAP's activities are conducted from its office in Penang, engaging in education, community mobilisation, research, advocacy, training, and publication.

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1.0

Introduction

The Industry's Rush into Electric Vehicles

The automotive industry shifted from its conventional trajectory toward the adoption of electric vehicles (EVs) due to multiple factors. These include long-term planning, government policies, technological advancements, and demand for cleaner alternatives due to climate urgency.

Key automakers and service groups such as the BMW group and Nissan are piloting second-life battery programmes, closed-loop recycling, and infrastructure frameworks that could shape Malaysia into a regional circular economy leader in electric mobility.

BMW Group Malaysia's RE:GENERATE programme[1] repurposes used EV batteries into portable chargers and energy storage systems, with the goal of building a local closed-loop battery system. While recovered materials are currently processed overseas, the company is exploring ways to keep more of this work within Malaysia.

Nissan's 4R Energy Corp model,[2] while not specific to Malaysia, is influencing local approaches. The model, which emphasises the refurbishment, reuse, resale and recycling of EV batteries, offers a global example of circular battery management that is being studied by industry players in the country.

Driving these industry steps to reduce their carbon footprint are tightening government regulations and growing competion for minerals.

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[1] BMW (17 January 2022). RE:GENERATE by BMW Group Malaysia – A Second Life Initiative Echoing Global Ambitions for Carbon Neutrality. https://www.bmw.com.my/en/topics/discover/news/2022-news/re-generate-by-bmw-group-malaysia.html

[2] Nissan Motor Corporation (27 January 2021). Nissan gives EV batteries a second life. https://www.nissan-global.com/EN/STORIES/RELEASES/4r/

Global Factors

An important factor in the emergence of EVs was the technological breakthroughs that made them practical. Most significantly, improvements in battery technology, particularly lithium-ion, made EVs more efficient and cheaper to produce. Tesla advanced the perception and established that EVs could be high-performance, technologically advanced and desirable, pushing legacy automakers to catch up.

Swelling numbers of eco-conscious consumers willing to switch to EVs also increased.[3] In a survey among 20,000 consumers from across 31 countries and territories, PwC found that consumers are increasingly prioritising sustainability in their consumption practices, as almost 85% say they are experiencing the disruptive impacts of climate change in their lives.[4] Government offers of tax incentives and subsidies has also made EVs financially attractive.

Climate change pressure and activism also contributed to the switch to EV. Activists and environmental groups pushed governments to take action against fossil fuels. Among the trigger events were the concerns of global warming caused by greenhouse gas (GHG) emissions, particularly carbon emissions in the 1980s, leading to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988.[5]

The rise of climate activism in the 2000s put stronger pressure on the industry.[6] In 2015, the Dieselgate scandal exposed Volkswagen's emissions cheating,[7] showing how the industry could fake its emissions data. This shifted the debate from eco-consciousness to corporate accountability. Car companies knew they had to switch faster amid growing pressure from governments. Further, Tesla's innovations pushed other companies to adapt or risk being left behind.

If these critical factors had not been present, traditional automakers would probably have maintained hybrid cars for a longer period.

Wave of policies and regulations of major countries from the European Union (EU), China, and USA introducing bans or phaseouts of internal combustion engine (ICE) vehicles, such as the EU's 2035 ban on new petrol and diesel cars contributed greatly to the development of EVs.[8] China's heavily subsidised EV development and monopoly of the supply chain, made it the world's largest EV producer, seller, as well as market.

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[3] The Wall Street Journal. Consumer (24 March 2024). 2024 Global Automotive Consumer Study: The Evolution of Mobility. https://deloitte.wsj.com/sustainable-business/2024-global-automotive-consumer-study-the-evolution-of-mobility-ea70756a?

[4] Consumers willing to pay 9.7% sustainability premium, even as cost-of-living and inflationary concerns weigh: PwC 2024 Voice of the Consumer Survey. https://www.pwc.com/gx/en/news-room/press-releases/2024/pwc-2024-voice-of-consumer-survey.html#

[5] IPCC. The Intergovernmental Panel on Climate Change. https://www.ipcc.ch/

[6] European Commission. European Green Deal: Commission proposes transformation of EU economy and society to meet climate ambitions (14 July 2021). https://transport.ec.europa.eu/news-events/news/european-green-deal-commission-proposes-transformation-eu-economy-and-society-meet-climate-ambitions-2021-07-14_en

[7] Clean Energy Wire (May 2020). "Dieselgate" - a timeline of the car emissions fraud scandal in Germany. https://www.cleanenergywire.org/factsheets/dieselgate-timeline-car-emissions-fraud-scandal-germany

[8] European Parliament (30-06-2023). EU ban on the sale of new petrol and diesel cars from 2035 explained. https://www.europarl.europa.eu/pdfs/news/expert/2022/11/story/20221019STO44572/20221019STO44572_en.pdf

Photo by Kindel Media

Malaysian Government's Promotion of EV

In Malaysia, the transportation sector is a significant contributor to GHG emissions, accounting for approximately 25% to 30% of the nation's total emissions.[9] This sector is the second-largest carbon dioxide (CO_2) emitter in the country, following the energy sector. Within the transportation sector, road transport is the predominant source of CO_2 emissions.[10]

Malaysia should be very concerned about carbon emissions because, while it is attempting to reduce its carbon footprint by switching to greener means to generate electricity, the high reliance on privately owned vehicles is a major factor contributing to these emissions. As of 2019, there are 29.4 million registered vehicles in Malaysia, including 13.8 million cars and 13 million motorcycles. This heavy usage of private transport has led to a disproportionately high per capita CO_2 emission of 7.27 tonnes, which is double that of Thailand and higher than China's 6.59 tonnes.[11]

According to Malaysia's Fourth National Communication to the UNFCCC[12]:

(i) Under the "Without Measures" (WOM) scenario, total emissions (excluding land use change) could reach 481,363 Gg CO_2 equivalent by 2030.

(ii) With existing mitigation efforts, emissions could drop to 367,603 Gg CO_2 equivalent, but this assumes some level of transition away from ICE vehicles.

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9 MGTC. Low Carbon Mobility Blueprint (LCMB). https://www.mgtc.gov.my/what-we-do/low-carbon-mobility-2/low-carbon-mobility-blueprint/

10 Solaymani, S. (2022). CO2 Emissions and The Transport Sector in Malaysia. Frontiers in Environmental Science. https://doi.org/10.3389/FENVS.2021.774164

11 MGTC. Malaysia's CO2 Emissions Among Highest In ASEAN, Low Carbon Mobility Solutions Needed. https://www.mgtc.gov.my/ms/2019/07/malaysias-co2-emissions-among-highest-in-asean-low-carbon-mobility-solutions-needed/

12 Malaysia's Fourth National Communication Report (NC4) submitted to the United Nations Framework Convention on Climate Change in April 2024. https://unfccc.int/sites/default/files/resource/NRES_NC4_To%20UNFCCC_2024%20v1.0.pdf

Electric vehicle (EV) development is one of the four focuses in Malaysia's National Industrial Master Plan 2030 (NIMP 2030). It is also one of the four new growth areas identified in the NIMP 2030. There are plans to install up to 10,000 charging stations to support the EV implementation in Malaysia.[13]

The Malaysian government, for its part, introduced several tax incentives and initiatives to encourage the adoption of EVs. Income tax relief was given to individuals who can claim up to USD 564 (RM 2,500) annually in income tax relief for expenses related to the installation, rental, or subscription of EV charging equipment at home. This incentive is available until the assessment year 2027.[14]

For electric motorcycles, a tax rebate of up to USD 541 (RM 2,400) is offered for their purchase. This incentive applies to the 2024 assessment year and is available to individuals with an annual income not exceeding USD 27,058 (RM 120,000)[15]. Companies that are renting non-commercial EVs can benefit from increased tax deductions. For vehicles costing up to RM 300,000, the tax deduction has been raised, effective from 2023 to 2025.[16]

Companies involved in the manufacturing of EVs, energy-efficient vehicles (EEVs), or related components may qualify for income tax exemptions. These include a 70% or 100% exemption on statutory income for a period ranging from five to ten years, depending on the nature and scope of the investment.[17]

The Ministry of Investment, Trade and Industry (MITI) announced that businesses investing in EV charging infrastructure can avail themselves of the Green Investment Tax Allowance (GITA). This provides a 100% tax exemption in the form of an investment tax allowance for five years, which can offset up to 100% of statutory income for each assessment year.[18]

MITI also stated that companies manufacturing EV charging equipment are eligible for a full income tax exemption on statutory income from the assessment year 2023 until 2032. Applications for this incentive must be submitted to the Malaysian Investment Development Authority (MIDA) between 25 February 2023 and 31 December 2025.[19]

Previously, most automakers were not in a rush as they had long-term EV plans, such as Toyota pioneering hybrids with the Prius in 1997. However, new players such as Tesla and BYD emerged and created the EV industry that challenged traditional automakers,

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[13] Malaysia's Fourth National Communication Report (NC4) submitted to the United Nations Framework Convention on Climate Change in April 2024.

[14] MalayMail (9 July 2024). Going EV: What the Malaysian government is doing to charge up the transition. https://www.malaymail.com/news/malaysia/2024/07/09/going-ev-what-the-malaysian-government-is-doing-to-charge-up-the-transition/141965

[15] Ibid.

[16] Tax Incentive for Company Renting Non-Commercial Electric Vehicle – CCS. (2023). https://ccs-co.com/post/tax-incentive-for-rental-of-electric-vehicle/

[17] Op cit. MalayMail (9 July 2024).

[18] MIDA (18 Nov 2024). MITI: Govt provides incentives for EV charging infrastructure development. https://www.mida.gov.my/mida-news/miti-govt-provides-incentives-for-ev-charging-infrastructure-development/

[19] Ibid.

forcing them to innovate or risk becoming obsolete.[20] With the success of Tesla and government regulations, legacy automakers were forced to accelerate their plans.

1.1 Material Composition of Electric Vehicle Batteries

EVs are powered by rechargeable battery packs, the most common being lithium-ion batteries (LIBs). These traction batteries supply the electrical energy required to drive the vehicle. Unlike traditional cars, EVs rely heavily on a vast array of minerals and advanced electronic components. A typical EV battery weighs around 450kg and consists of thousands of lithium-ion cells grouped into modules and packs.

The cells themselves are composed of critical materials including graphite, aluminium, copper, lithium, nickel, cobalt and manganese. These batteries are commended for their high energy density and efficiency, but their production entails substantial extraction and processing of raw materials, often sourced under environmentally harmful and exploitative conditions.[21]

[20] LinkedIn (28 August 2023). 6 Reasons why Legacy Automakers are unlikely to be in a strong position by 2030. https://www.linkedin.com/pulse/6-reasons-why-legacy-automakers-unlikely-strong-position-wilson

[21] GAIA 2024. Understanding Basics of Electric Vehicle Batteries. https://www.no-burn.org/wp-content/uploads/2024/06/01-Battery-Infosheet-Understanding-Basics-of-EV-Batteries.pdf

2.0

The Current EV Battery Scenario and Issues in Malaysia

There is a need to examine the growth of EVs in Malaysia over a period of time to understand the present and future acceptance of these technologies, as EV lithium-ion batteries (LIBs) are closely associated. Thus, EVs must be considered not only from a Malaysian perspective but also within a global context.

EVs were first launched in 2013.[22] The number of EVs registered nationwide did not exceed 400 per month until April 2022, when the number of registered EVs started to spike steeply, reaching a total of 50,053 EVs in October 2024.[23] According to the Malaysian Investment Development Authority (MIDA), the EV LIB market is expected to grow at an annual rate of 5.28% from 2022 to 2027 in Malaysia.[24] Hence, EVs are relatively new in Malaysia, but with the recent conflict in the Middle East, the Road Transport Department reported 5,894 new EV registrations in April 2026, a sharp 103.8% increase from 2,892 units recorded during the same month last year.

Based on an estimated eight-year battery lifecycle and EV registration trends since 2020, around 40,000 batteries were projected to require recycling by 2030, rising to 330,000 by 2040 and 870,000 by 2050, according to the Malaysia Automotive, Robotics and IoT Institute (MARii).

If systems remain unprepared, these EV batteries could end up in landfills, choking rivers, and exploding in households due to improper disposal. They could also pose serious environmental and public health risks due to the hazardous materials they contain.[25]

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[22] ExpatGo (17 August 2013). Electric Cars in Malaysia: An Overview. https://www.expatgo.com/my/2013/08/17/electric-car-malaysia/# .

[23] Data.gov.my (accessed 10 November 2024). Vehicle Registrations. https://data.gov.my/dashboard/vehicle-registrations

[24] MIDA (24 September 2024). Malaysia sets for growth in EV battery, e-waste recycling market. https://www.mida.gov.my/mida-news/malaysia-sets-for-growth-in-ev-battery-e-waste-recycling-market/

[25] The Star. (2026, May 21). Malaysia moves to tackle future EV battery waste challenge. Asia News Network. https://asianews.network/malaysia-moves-to-tackle-future-ev-battery-waste-challenge/

Year	2022	2023	2024	Total
No of EVs registered with JPJ*	3,017	13,144	21,788	37,949

** JPJ – Road Transport Department. Source: https://data.gov.my/data-catalogue/registration_transactions_car*

Malaysia has a long way to go in replacing conventional public land transport with energy-efficient vehicles (EEVs). In 2022, it was reported that only 66 buses were operating nationwide, compared to approximately 340 electric buses being registered daily in China and more than 8,500 in operation across Europe.[26]

The Pan Malaysian Bus Operators Association (PMBOA) president explained that a European EV bus can cost up to USD 600,000 (RM 2.5 million), while a China-made bus can cost up to USD 400,000 (RM 1.8 million). Additionally, costly repairs and maintenance must be considered. There is also a lack of charging stations, a shortage of mechanics skilled in EV maintenance, and a pressing need for more EV workshops.[27]

The Malay Mail reported that by 2050, Malaysia will need to process 870,000 depleted EV batteries[28], for which robust systems for collection, processing and material recovery are critical. Based on an eight-year battery lifecycle and EV registration data from 2020, projections indicate that 40,000 EV batteries will require recycling by 2030, rising to 330,000 by 2040 and 870,000 by 2050.

In anticipation of this growth in EV battery waste, the Malaysia Automotive, Robotics and IoT Institute (MARii) is spearheading the development of a Battery Passport initiative. This digital record system will track key battery information, including composition, origin, lifecycle data, and recyclability, ensuring efficient resource management and compliance with global sustainability standards.[29]

There are two Department of Environment (DoE)-licensed Authorized Automotive Treatment Facilities (AATF) i.e. Car Medic Sdn Bhd and Jaring Metal Industries Sdn Bhd. MARii is actively promoting licensed AATFs, sanctioned by the DoE, to manage used parts and components from EOL vehicles (ELV) and EOL Parts (ELP).

There are four scheduled waste recycling facilities — Hi Tech Full Recovery (M) Sdn Bhd, Mep Enviro Technology Sdn Bhd, SungEel Hitech Sdn Bhd, Tes-Amm (M) Sdn Bhd — approved by the DoE for processing SW103-type wastes, including batteries containing cadmium, nickel, mercury, or lithium.[30]

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[26] The Malaysian Reserve (2 April 2025). Low electric bus adoption due to high costs. https://themalaysianreserve.com/2023/12/27/low-electric-bus-adoption-due-to-high-costs/

[27] Ibid.

[28] MalayMail (5 March 2025). By 2050, 870,000 EV batteries will need recycling: How is Malaysia tackling the challenge? https://www.malaymail.com/news/malaysia/2025/03/05/by-2050-870000-ev-batteries-will-need-recycling-how-is-malaysia-tackling-the-challenge/167510

[29] Yiswaree Palansamy (Malay Mail. 5 March 2025) By 2050, 870,000 EV batteries will need recycling: How is Malaysia tackling the challenge? https://www.malaymail.com/news/malaysia/2025/03/05/by-2050-870000-ev-batteries-will-need-recycling-how-is-malaysia-tackling-the-challenge/167510

[30] Ibid.

Reprocessing used electric vehicle (EV) batteries is important because it helps recover valuable materials such as lithium, cobalt and nickel, reducing the need for environmentally damaging mining. Proper recycling also prevents hazardous substances from polluting the environment and enables a circular economy where components are reused in new batteries or other applications. As the global demand for EVs increases, so does the volume of end-of-life batteries, making efficient processing crucial for sustainability, resource conservation and carbon emissions reduction across the battery lifecycle.

3.0

Disadvantages and Challenges of Electric Vehicles and their Battery

3.1 Mining of Rare Earth and Critical Minerals

Non-Radioactive Rare Earth Elements (NR-REE) are usually found in ion-adsorption clays, particularly in tropical and subtropical regions such as Malaysia, China, Myanmar, and Vietnam. They are usually used in magnets (for EVs and wind turbines), electronics, defence systems, and green energy technologies. The term non-radioactive is used to define some REE, although these minerals all contain naturally occurring radioactive materials (NORM).

NR-REE are not directly used in EV batteries, but they play a crucial role in EV motors and other components, such as neodymium (Nd), praseodymium (Pr), dysprosium (Dy), and terbium (Tb) are essential for making neodymium-iron-boron (NdFeB) magnets. These high-performance magnets are used in permanent magnet synchronous motors (PMSM), found in EVs from Tesla, Toyota, and BYD. They are critical for the EV drivetrain, especially in motors using rare-earth magnets.

Lanthanum (La) and cerium (Ce) are used in fuel cells and battery additives. Some REEs help improve battery efficiency and sensor performance.

Some companies (e.g. Tesla in its latest Model 3 Refresh) are developing rare-earth-free motors, but NR-REEs are still dominant due to their efficiency and high power-to-weight ratio. So while NR-REEs may not be found inside the battery, they are vital for EV motor performance, making them a key material for EVs.

Malaysia has a history of issues with radioactive REE processing and waste disposal, for instance, the Lynas' rare earth refinery controversy and the Asia Rare Earth (ARE) Sdn Bhd radioactive pollution in Bukit Merah, Perak.

As Malaysia possesses substantial REE reserves, the country is actively pursuing "sustainable" REE mining. However, REE mining and processing pose devastating environmental and health risks. Nevertheless, NR-REE mining activities, NR-REE mining activities in Malaysia have been approved or initiated in several locations across different states, among them:

- **Kenering, Hulu Perak**: A pilot NR-REE mining project commenced operations in October 2022 on an 84.6-hectare site. From February to November 2023, the state government reported receiving RM21.1 million in royalties from this venture. Three additional districts in the state of Perak i.e. Kuala Kangsar, Kinta, Larut Matang & Selama, with large REE reserves have been identified.[31]
- **Sungai Wang, Hulu Jelai sub-district, Lipis, Pahang**: In April 2024, the Pahang state government approved a 220-hectare area in Sungai Wang for its pioneer NR-REE mining project. The standard operating procedures for this project were being finalized as of May 2024. Other areas identified for REE mining in the state of Pahang are Bentong and Raub.[32]
- **Negeri Sembilan**: In November 2024, the state government approved two sites totalling approximately 400 hectares for NR-REE mining. The standard operating procedures for these projects had been finalized after several revisions. Two sites in Jelebu have been identified with pilot projects planned to start in 2026 and revenue expected in 2027.[33]
- **Ulu Slim, Tanjung Malim, Perak**: The presence of NR-REE has been acknowledged in these areas, although detailed information and assessments regarding their economic viability were pending as of December 2023.[34]

Malaysia does not have significant deposits of lithium, cadmium, cobalt, or other key EV battery minerals compared to major mining countries. Rather than mining these critical minerals, Malaysia is positioning itself as a hub for battery production, attracting investments in battery manufacturing and recycling.

Lithium is primarily mined in Australia, Chile, Argentina, and China; cobalt in the Democratic Republic of the Congo, Russia, and Canada; while cadmium, a by-product of zinc mining, is extracted in China and South Korea, with Japan dominating global output. Neighbouring countries like Indonesia and the Philippines lead in nickel and cobalt production at competitive costs. Extracting lithium and cobalt requires vast infrastructure, energy, and water resources.

In general, there are two methods to mine rare earth minerals. The first is the conventional open-cast mining; the second is in-situ leaching method. Both methods present serious environmental and health impacts. While open-cast mining requires a larger-scale clearing of vegetation and forests and the removal of topsoil, in-situ leaching needs to clear a third of existing vegetation.

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[31] MalayMail (13 Dec 2023). Perak MB acknowledges presence of non-radioactive rare earth elements beyond Hulu Perak district. https://www.malaymail.com/news/malaysia/2023/12/13/perak-mb-acknowledges-presence-of-non-radioactive-rare-earth-elements-beyond-hulu-perak-district/107373

[32] TheEdge (10 May 2024). Sg Wang in Lipis approved as pioneer non-radioactive rare earth element mine, Pahang state assembly told. https://www.klsescreener.com/v2/news/view/1323275/sg-wang-in-lipis-approved-as-pioneer-non-radioactive-rare-rarth-element-mine-pahang-state-assembly-told

[33] TheStar (6 November 2024). Negri greenlights two sites for rare earth elements mining. https://www.thestar.com.my/news/nation/2024/11/06/negri-greenlights-two-sites-for-rare-earth-elements-mining

[34] Op cit. MalayMail (13 Dec 2023).

NR-REE mining carries severe environmental and health risks. Water pollution is one of the most immediate concerns, as mining operations often expose sulphide minerals, which react with water and oxygen to produce sulphuric acid. This acid can leach heavy metals into water sources, contaminating rivers and groundwater. Elements such as arsenic, lead, and cadmium, often found alongside NR-REEs, pose long-term health risks, particularly to indigenous communities and others reliant on natural water sources.

Mining operations generate fine particulate matter containing toxic heavy metals, which can cause respiratory issues. Miners are exposed to hazardous dust and chemical fumes, increasing the risk of lung diseases and cancers.[35] Additionally, toxic tailings and acid drainage degrade soil quality, making land unsuitable for agriculture or reforestation. Deforestation caused by mining leads to soil erosion and loss of vegetation cover, while chemically treated waste further harms ecosystems.

Malaysia's rare earth element (REE) deposits are located in high carbon stock areas such as forests, which are crucial in providing resilience against disasters, carbon sequestration and water regulation. Photo from: The Edge Malaysia

Clearing forests and ecosystems for mining results in biodiversity loss, worsening Malaysia's existing environmental challenges. Polluted water affects aquatic life, disrupting entire ecosystems and harming communities dependent on rivers for drinking water and livelihoods. Contaminated water and air pollution can lead to chronic health conditions, including kidney disease, neurological disorders, and reproductive problems.

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35 Challenges (April 2023). Habeebullah Jayeola Oladipo et al. Global Environmental Health Impacts of Rare Earth Metals: Insights for Research and Policy Making in Africa. https://www.researchgate.net/publication/369781143_Global_Environmental_Health_Impacts_of_Rare_Earth_Metals_Insights_for_Research_and_Policy_Making_in_Africa

Large-scale mining projects often compel indigenous and rural communities to relocate, disrupting their traditional way of life. A notable example involves the Semai Orang Asli of Pos Lanai in Pahang, who have been protesting since around 2019 against a proposed rare earth element mining project. The community argued that the mining activity would harm their ancestral forest, contaminate the Telum River, and destroy their customary sources of water and food. Although the state approved the project, its initial Environmental Impact Assessment report was not approved.[36]

Non-governmental organisations and indigenous networks, such as Sahabat Alam Malaysia (SAM) and Jaringan Orang Asal SeMalaysia (JOAS), have issued open letters calling for adherence to the principle of Free, Prior and Informed Consent. Furthermore, mining operations can give rise to exploitative labour practices and disputes over land use with local communities. In certain instances in Malaysia, rare earth mining has been carried out illegally, worsening environmental degradation and fuelling social tensions.

Given these risks, Malaysia must weigh the economic benefits of NR-REE mining against its long-term environmental and social costs.

3.2 EVs are Not Truly Zero-Emissions

While EVs are marketed as zero-emission vehicles, this label only applies to tailpipe emissions. EVs still produce substantial GHG emissions across their lifecycle, from mining and manufacturing to disposal and recycling.

The production of LIBs is highly resource-intensive, often causing deforestation, pollution, and high energy and water use. Solid-state batteries require 35% more lithium compared to conventional lithium-ion batteries. Although recycling helps, it still involves emissions and environmental costs.

Thus, EVs' carbon footprints must be assessed from a full lifecycle perspective. The "zero-emission" label can be misleading, as EVs—while reducing local air pollution—still carry substantial environmental burdens.

According to a recent Greenpeace East Asia report[37], electricity use and cathode material production are the two largest sources of emissions in lithium-ion battery manufacturing. Battery manufacturing, which is responsible for roughly one-third of cradle-to-gate CO2 emissions, is highly dependent on the carbon intensity of the local grid.

While local data is limited, global benchmarks suggest that producing a typical lithium-ion EV battery (around 40–60 kWh) emits 2 to 5 tonnes of CO2 equivalent, depending on energy sources and supply chain efficiency.

[36] TheEdge (20 June 2024). Social: A blind spot in the transition? https://theedgemalaysia.com/node/715527

[37] Hang Bao, Jiacheng Li, Yujing Zhang. 2025. Charging Toward Zero Emissions: Evaluating Climate Progress by Top EV Battery Manufacturers. Greenpeace East Asia. https://www.greenpeace.org/static/planet4-eastasia-stateless/2025/07/306a9bac-charging-toward-zero-emissions_final_en.pdf

3.3 High Cost and Limited Accessibility

EVs remain largely unaffordable for the average Malaysian due to their high upfront purchase prices, costly maintenance, and additional expenses such as charging infrastructure, repairs, and component replacements. Battery repairs are expensive, sometimes exceeding RM44,350 with minor faults often requiring full battery replacement. This can lead to early vehicle scrapping and environmental waste.[38]

As of 2024, only 37,949 EVs were registered nationwide, reflecting slow adoption driven by affordability issues and an immature market.

3.4 Infrastructure and Charging Limitation

Malaysia's EV infrastructure remains underdeveloped, with limited public charging stations, especially outside urban areas, causing "range anxiety" and deterring long-distance EV use.[39] Although the government has introduced incentives, such as the Green Investment Tax Allowance (GITA), implementation has been slow.

There is also a shortage of skilled personnel to service EVs. Most local mechanics lack the tools and training to handle the unique requirements of EVs, including specialised systems like the air conditioning system.[40] Moreover, many EV brands restrict servicing to authorised centres, adding to user inconvenience and costs.

Figure 1: Issues of Battery Repairability (Source: GAIA 2024)

Technically challenging

More than 50% of battery failures occur at module-level, and only a few specialized refurbishment centers can repair this.

Prohibitively expensive

Even if repair is possible, it is prohibitively expensive. As a result, the vehicle is instead scrapped by the consumer or insurer.

Sometimes impossible

Repair is sometimes technically impossible when proprietary technology shuts the battery down, or when cells are bonded directly to the pack

[38] GAIA 2024. The Right to Repair of Electric Vehicle Batteries. https://www.no-burn.org/wp-content/uploads/2024/06/03-Battery-Infosheet-The-Right-to-Repair-of-Electric-Vehicle-Batteries.pdf

[39] Challenges and Solutions for EV Range Anxiety. (2024). https://www.buyev.my/resources/article/challenges-and-solutions-for-ev-range-anxiety#:~:text=Defining%20the%20Challenge:%20Range%20Anxiety%20Range%20anxiety,this%20clean%20and%20sustainable%20mode%20of%20transportation.

[40] Shamsul Yunos. (2024). The Challenge of Skilled Labour in Malaysia's Energy and EV Transition. https://www.nst.com.my/news-cars-bikes-trucks/2024/09/1100417/challenge-skilled%C2%A0labour%C2%A0-malaysias-energy-and-ev-transition

3.5 Limited Battery Lifespan and Performance Issues

While EV batteries are often highlighted for their efficiency, they have limited lifespans, typically 8 to 15 years, and begin to degrade well before that, reducing range and performance. High temperatures, common in tropical countries like Malaysia, can accelerate this degradation, impacting battery reliability and longevity.[41] These limitations raise concerns about the long-term sustainability and cost-effectiveness of EVs, especially in lower-income countries where affordability and durability are critical concerns.

3.6 EV Battery Recycling in Malaysia

At present, there are too few lithium-ion batteries (LIBs) waste available to sustain EV battery recycling plants in Malaysia. This may open the gate for the import of used batteries to make it financially viable for the recycling plant. Furthermore, LIB technology is still evolving and may eventually be replaced by alternatives such as sodium-ion, solid-state, zinc-ion, aluminium-ion, flow batteries, or iron-air batteries—each offering advantages such as lower cost, increased safety, or higher energy density. When LIBs are replaced, recycling plants will face challenges in adapting to different chemistries and materials.

At present, there are too few lithium-ion batteries (LIBs) waste available to sustain EV battery recycling plants in Malaysia. This may open the gate for the import of used batteries to make it financially viable for the recycling plant.

Assuming that the early EV LIBs also have a lifespan of 10 to 20 years, it would be about time for the batteries of the first batch of EV to head for the recycling plants in 2024, but the number is very small and may not be commercially viable unless the two existing recycling plants import EV LIBs in the interim period to meet their recycling capacity. The batteries of EV that were registered in 2022 would only reach their End of Life (EOL) in the early 2030s.

3.6.1 Case Study: EcoNiLi Battery

EcoNiLi Battery, a Singapore-based lithium-ion battery recycling firm, with a plant in Ipoh in the state of Perak, currently sources its used battery supply domestically and from local firms that have imported battery scraps, including shredded materials, from regions like Europe and the US.[42]

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[41] Geotab. (2025). EV Battery Health Insights: Data From 10,000 Cars https://www.geotab.com/blog/ev-battery-health/

[42] Argus (26 March 2024). Q&A: Battery recycling gets competitive: Clarification. https://www.argusmedia.com/en/news-and-insights/latest-market-news/2551238-q-a-battery-recycling-gets-competitive-clarification

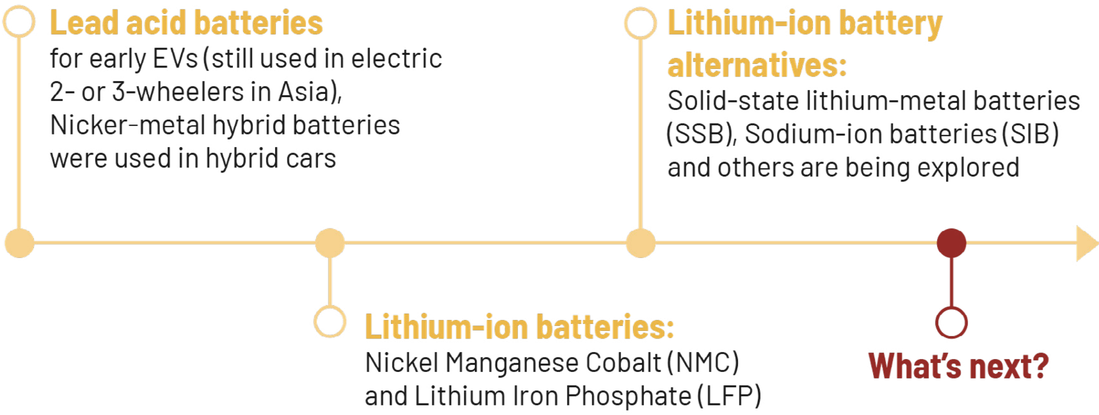

Figure 2: History of EV Battery Evolution (Source: GAIA 2024)

The company exports its processed black mass primarily to customers in Hong Kong, who then send it to China, as well as to South Korea. Moving forward, EcoNiLi plans to export directly to Chinese customers under offtake agreements[43], having already secured four buying contracts for this purpose.

EcoNiLi, with an estimated annual recycling capacity of 24,000 tonnes, is reportedly in talks with the trade ministry to secure a green channel that would permit the direct import of battery scraps, which is currently restricted.[44]

CAP sees this as a precedent for other EV LIBs recycling plants to do the same, eventually leading to the government finding it difficult to monitor or stop future imports if EV battery recycling becomes detrimental to the environment.

It was reported that the Singapore-based company chose Malaysia because it would cost US$798 (5,800 Yuan) per tonne to treat the batteries in Singapore, compared to just US$206 (1,500 Yuan) in Malaysia. Establishing its operations across the border increased EcoNiLi's profit by almost four-fold for the same quantity of EV LIBs processed.

A parallel can be drawn to the Lynas Advanced Materials Plant (LAMP) in Gebeng, Pahang, a rare earth processing facility operated by Australian company Lynas Rare Earths Ltd. LAMP is unable to send its radioactive waste back to Australia due to various legal, regulatory, and logistical reasons.

Similarly, land-strapped Singapore would certainly not allow EcoNiLi's production waste to enter the country. Neither is it logistically nor financially viable to send the waste back, as the high costs would undermine the very reason for operating in Malaysia.

[43] An 'offtake agreement' is a contractual arrangement between a producer and a buyer, where the buyer commits to purchase a portion or all of the producer's future output. This type of agreement provides both parties with security—the producer is assured of a market for its product, while the buyer secures a steady supply of goods at predetermined terms. These agreements are common in industries like energy, mining, and manufacturing, as they help secure financing and reduce risks by offering predictable revenue streams and supply assurances. In essence, an offtake agreement lays out the terms and conditions under which products will be sold and purchased over a specified period, benefiting both the supplier and the customer.

[44] Ibid.

The company admitted that it was the first black mass producing factory in Indonesia in 2019 but was unable to collect enough used batteries due to Indonesia's ban on used battery imports.[45]

3.6.2 Other EV Battery Recycling Plant Proposals

Ni Hsin EV Tech Sdn Bhd, a subsidiary of Ni Hsin Group Bhd, announced in December 2022 a strategic collaboration with SIRIM Berhad to establish a LIB recycling plant in Malaysia.

The initiative aimed to address environmental concerns associated with the improper disposal of LIBs and to promote a circular economy. The pilot plant was projected to be fully operational in 2023, with an annual recycling capacity of 550 tonnes of LIBs.[46] Initially, black mass extracted in the process is planned to be sold to LIBs manufacturers before launching into LIB manufacturing from 2025.

However, it was reported in March 2024 that Ni Hsin EV Tech has terminated its collaboration with SIRIM, effectively shelving the plan to develop the lithium-ion battery recycling plant.[47] On the contrary, it announced the launch of its electric motorcycle and electric scooter range in 2024.

3.6.3 Recycling of EV batteries and their cost

The recyclable materials in EV batteries are nickel, cobalt, and manganese found in the cathode; graphite that can be found in the anode; lithium in the electrolyte or active materials; copper and aluminium, in current collectors and battery casing.

Our main concerns about EV batteries are:

- **Electrolytes** composed of organic solvents degrade over time and also the thin plastic layers often comprising either polyethylene or polypropylene which are contaminated with solvent residue.
- **Binders** that are made up of Per- and Polyfluorinated Substances (PFAS) being reputed as "forever chemicals". PFAS used to bind the active materials to the electrodes, are generally not recyclable due to their chemical nature. They are resistant to environmental breakdown and can persist in ecosystems and human bodies, with exposure linked to a range of health risks, including cancer and hormone disruption.
- **Plastic parts** and other hazardous substances that may end up in landfill or burned indiscriminately.

[45] Ibid.

[46] Renewable Energy Magazine (15 December 2022). Ni Hsin signs agreement with SIRIM for new lithium-ion battery recycling plant. https://www.renewableenergymagazine.com/storage/ni-hsin-signs-strategic-collaboration-agreement-with-20221215

[47] MT Newswires (11 March 2024) Ni Hsin, SIRIM Shelve Plans to Develop Lithium-Ion Battery Recycling Plant. https://in.marketscreener.com/quote/stock/NI-HSIN-RESOURCES-20702923/news/Ni-Hsin-SIRIM-Shelve-Plans-to-Develop-Lithium-Ion-Battery-Recycling-Plant-46137872/

Table 2: Battery composition

Material	Composition range (% of total average battery weight)
Nickel, cobalt, and manganese	30 ~ 50
Graphite	10 ~ 20
Electrolyte	10 ~ 15
Aluminium and copper	15 ~ 20
Binders and separators	3 ~ 5
Other structural components (plastic and steel casings)	5 ~ 10

Since we do not anticipate enough volume of EV batteries for recycling to meet with the capacity of the existing recycling plants in Malaysia at least until 2030 and beyond, it is expected that these plants will have to import batteries for recycling. Unrecyclable materials will end up in landfills or as environmental pollutants.

Batteries may be deemed unsuitable for use in EV when their capacity has reached 70% to 80%. These will then be repurposed for other uses such as for community solar projects as renewable energy storage. This will only delay their schedule to the recycling plant.

The widespread push for EV adoption, supported by government incentives and regulations, may unintentionally promote environmentally harmful economic activities in related sectors. For example, the government, in giving incentives for the recycling of EV batteries, will actually be aiding recycling plants to supplement their shortfall in recycling capacity with imported batteries, without which the plant will not be economically viable.

The recent decline in EV battery prices (approximately 10% in 2023[48]) is projected to continue, potentially falling by another 50% by 2026 according to Goldman Sachs.[49] This trend poses challenges for recycling centres for two main reasons:

1. **Reduced Material Value**: Lower battery prices can diminish the value of recovered materials (e.g., lithium, cobalt, and nickel), reducing profitability for recyclers who depend on these sales.

[48] EV, energy storage battery prices set to fall more, report says. https://www.reuters.com/technology/ev-energy-storage-battery-prices-set-fall-more-report-2023-09-07/#

[49] EV battery prices to fall by nearly 50 pct and near ICE parity by 2026, says Goldman Sachs. https://thedriven.io/2024/10/16/ev-battery-prices-to-fall-by-nearly-50-pct-and-near-ice-parity-by-2026-says-goldman-sachs/

2. **Competition with Newly-Mined Materials**: Lower-cost, newly-mined materials could outcompete recycled alternatives, especially if mining costs remain low and supply is sufficient. This makes recycling investments less attractive for businesses.

To sustain and encourage recycling efforts, the government has to provide incentives, which ironically, come from taxpayers who will eventually be impacted by the toxic recycling by-products of EV batteries.

Since EVs in Malaysia are relatively recent, it is an opportunity for us to monitor the development and impact on the environment of end-of-life management of EV batteries. From the lessons learned, it may offer a different perspective of how we can navigate the lure of 'green energy'.

4.0

Recommendations

4.1 Rethinking EV Design Through a Zero Waste and Resource Efficiency Lens

To address the pressing challenges of EV battery recycling and environmental sustainability, Malaysia should adopt a Zero Waste approach that prioritises systems redesign and materials conservation over downstream solutions like recycling. This involves rethinking how cities and mobility systems are designed, favouring efficient, accessible and decentralised transport and energy systems that reduce overall resource demand.

By aligning EV development with the Zero Waste Hierarchy and addressing the root causes of linear material use, Malaysia can ensure that EV development contributes to a sustainable, resilient, and equitable transition, rather than replicating extractive and polluting models.

4.2 Reducing Lifecycle Emissions

To genuinely reduce emissions, Malaysia should adopt lifecycle carbon accounting for EVs, promote lighter and smaller EV designs, and support the development of energy-efficient vehicles. Further, integrating EVs into a broader sustainable transport strategy that includes public transit, shared mobility, and non-motorised transport is essential for maximising environmental benefits.

4.3 EV Charging Infrastructure

The expansion of the EV charging network should prioritise integration with renewable energy sources, particularly solar energy. Malaysia's equatorial location provides abundant sunlight, making solar-powered EV chargers a viable and sustainable solution. Installing photovoltaic (PV) panels on rooftops, car parks and highway rest stops can reduce reliance on fossil-fuel-based grid electricity and lower the carbon footprint of EV charging.

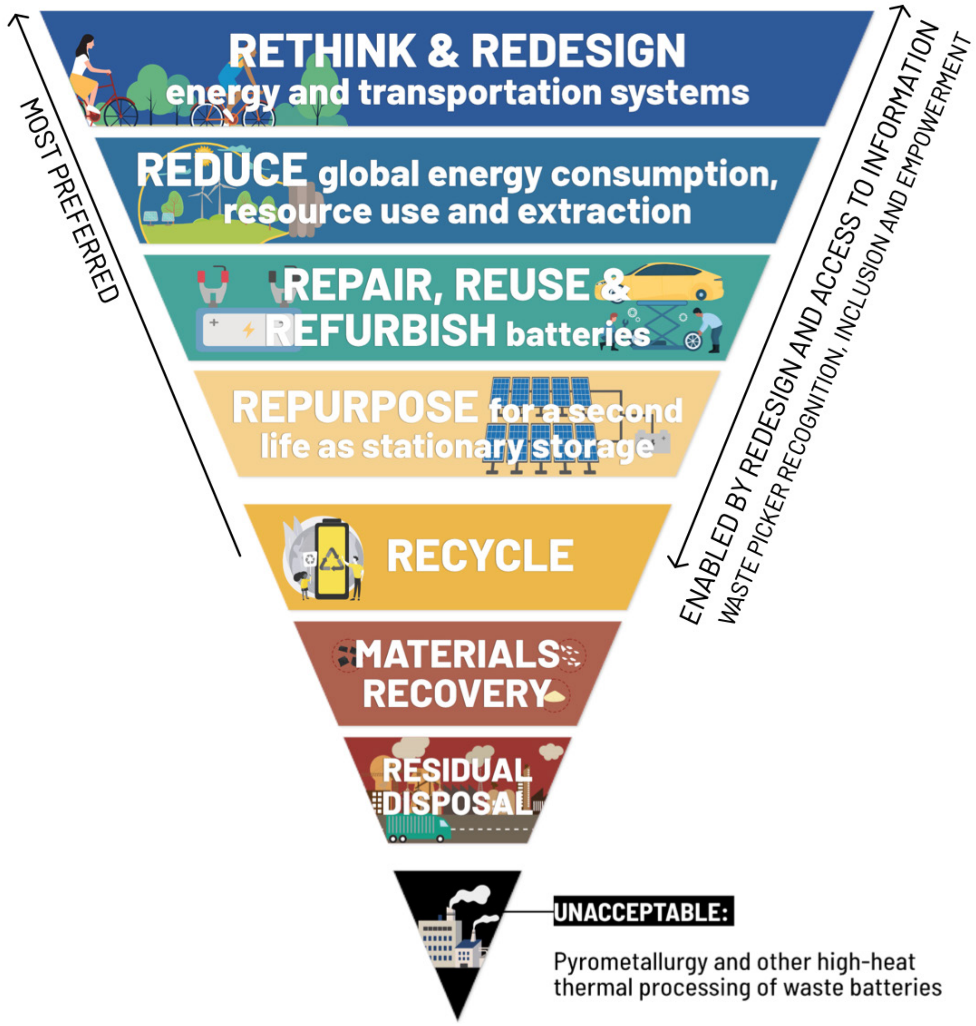

Figure 3: Zero Waste Hierarchy For Batteries (Source: GAIA 2024)

By aligning EV development with the Zero Waste Hierarchy and addressing the root causes of linear material use, Malaysia can ensure that EV development contributes to a sustainable, resilient, and equitable transition, rather than replicating extractive and polluting models.

4.4 Extending Battery Lifespan and Utility

Many EV batteries are discarded prematurely when their capacity falls below 70% to 80%, despite remaining suitable for secondary uses. Battery designs that hinder repair and reuse exacerbate this issue. Malaysia should promote the right to repair by requiring manufacturers to make diagnostic tools, spare parts and technical information publicly available. Regulatory standards should also mandate modular battery construction to facilitate easy maintenance, refurbishment, and reuse. Supporting battery repair technician training programmes can further extend battery service life and reduce waste.

4.5 Second-Life Applications

EV LIBs can still retain value even after reaching the end of their automotive life. While they may no longer be suitable for powering EVs due to reduced capacity, typically below 70–80% of their original performance, they can be repurposed for less demanding applications.

Rather than being discarded, used EV LIBs can serve as energy storage solutions, particularly for storing excess energy from renewable sources such as solar and wind. This allows for a more stable power grid by releasing stored energy when demand is high. Additionally, these batteries can be integrated into solar panel systems to provide backup power, reducing reliance on the electrical grid.

Beyond large-scale energy storage, degraded EV batteries can be reconfigured for smaller applications, including charging stations and off-grid power solutions. However, several challenges remain. Used LIBs may have inconsistent performance, necessitating extensive testing and reconditioning before they can be safely reused.

The lack of standardisation across manufacturers, who employ different battery chemistries and formats, further complicates large-scale repurposing efforts. In some cases, the cost of recycling or repurposing old batteries may outweigh the economic benefits, making new battery production a more viable option.

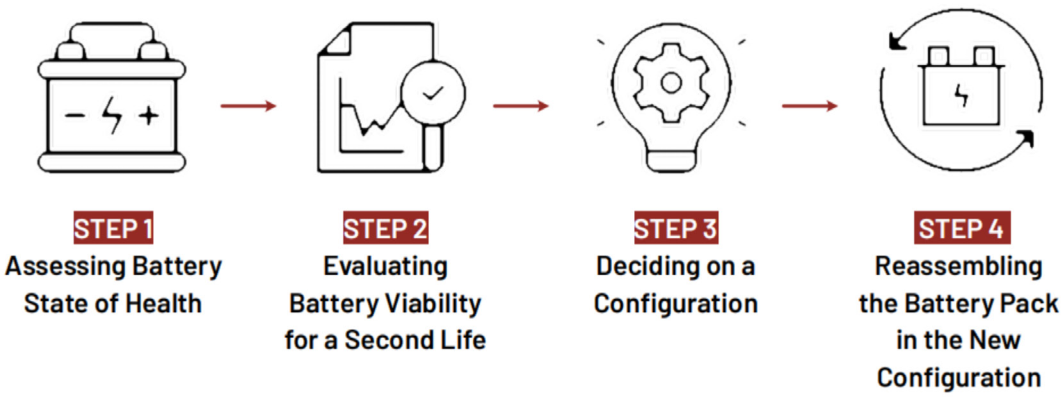

Figure 4: Four Steps of Battery Repurposing (Source: GAIA 2024)

4.6 Strengthen EV Battery End-of-Life Management

Most local EV batteries will only reach end-of-life after 2030. In anticipation of future volumes, Malaysia should implement a clear regulatory framework based on Extended Producer Responsibility (EPR). Manufacturers and importers must be legally required to collect and manage used batteries in proportion to their sales, with penalties for non-compliance and incentives for sustainable design. EPR schemes should prioritise repair over recycling. Only licensed and trained companies should be permitted to manage used EV batteries under strict safety and environmental standards, with regular inspections enforced.

4.7 Promote Battery Passport Initiative

The government should spearhead the development and implementation of the Battery Passport initiative, which is a digital tracking system that records key information about each EV battery, including its composition, origin, usage history and recyclability. This system will enable better resource management, facilitate safer and more efficient recycling processes and ensure compliance with international sustainability standards.

By making battery data transparent and accessible, the Battery Passport will also help identify batteries suitable for reuse or repurposing, as well as those that require safe dismantling and disposal. This initiative supports a circular economy approach and strengthens Malaysia's position in sustainable battery management.

LABEL	DISMANTLING	COMPOSITION	STATE OF HEALTH
Manufacturer, battery type, date of production, capacity, hazardous substances	Detailed composition, replacement parts, dismantling instructions, replacement parts, safety information	Chemistry, carbon footprint, sourcing, responsible sourcing, rated capacity, expected lifetime, etc.	Performance, state of health, history of use and negative events

Figure 5: Battery Passport Content (Source: GAIA 2024)

4.8 Reducing Private Vehicle Use and Investing in Public Transportation

Rather than solely switching from ICE vehicles to EVs, the government should focus on promoting the use of public transport. As of October 2024, there were 27,893,731 registered vehicles of various types in Malaysia. Policies must be formulated to

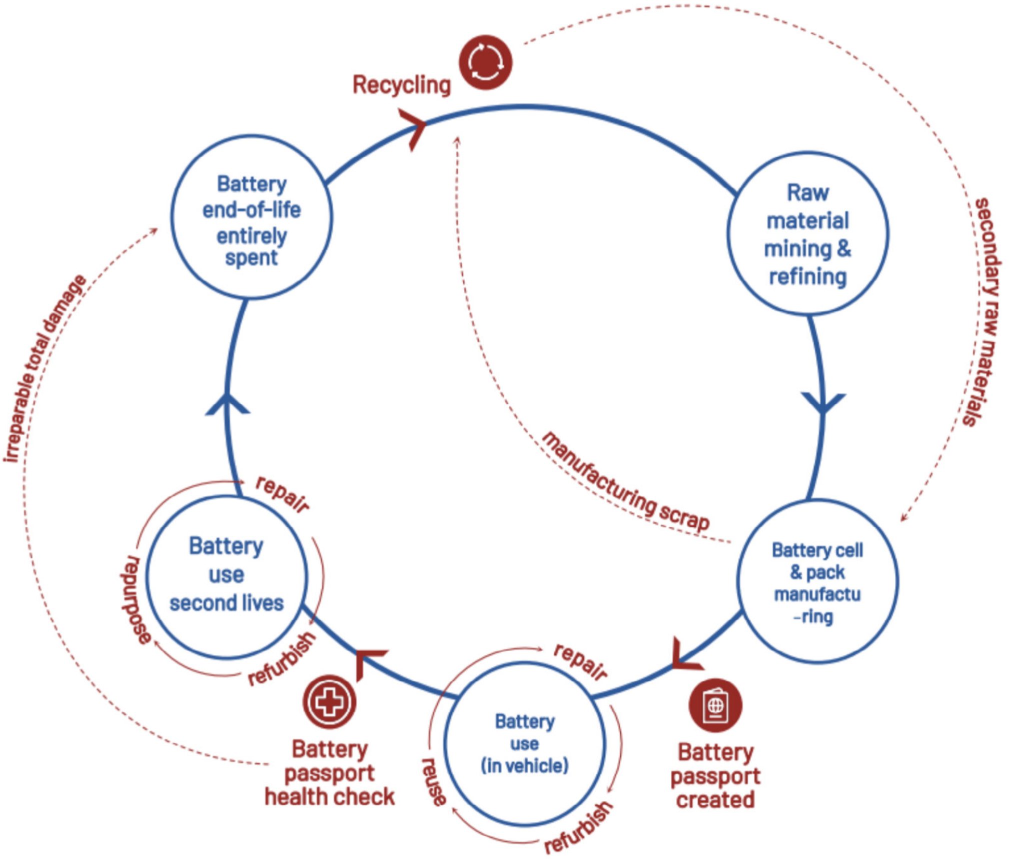

Figure 6: Zero Waste Material Flow in the EV Battery Life Cycle (Source: GAIA 2024)

discourage private vehicle use, but it will take years for car owners to transition to public transport.

Encouraging public transport or ridesharing is more cost-effective, as it reduces the number of vehicles on the roads. However, one of the major challenges faced by public transport operators is the low number of passengers, making it difficult to sustain operations without financial losses. Key considerations include:

Public transport adoption takes time. It will take decades for people to switch to public transport while they still own private vehicles. Public transport should likely be managed by a government-linked company (such as Prasarana) since private companies may not survive if the initial ridership is low.

Demand-responsive transit (DRT). In August 2024, Rapid Penang introduced DRT services, offering van transport for first- and last-mile connections to the existing Rapid Penang network, improving public transport connectivity.

Factors that encourage higher bus ridership are:

- **Affordability**. While affordability is subjective, policies should use the B40 income group as a baseline. Profitability should be a secondary concern, which

is why public transport should be government-operated and partially funded by taxpayers.
- **Convenience**. DRT services can encourage commuters to park-and-ride at public transport stations by offering flexible last-mile transport options.
- **Punctuality**. Reliable timetables allow commuters to plan their journeys more efficiently.
- **Regularity**. Frequent trips along key routes enable better trip planning.

Punctuality and regularity are among the most important factors in evaluating public transport services. A reasonable interval for popular routes would be 10 to 20 minutes.

Malaysia can implement electrified public transport systems effectively by combining strong policy frameworks, strategic investments, and inclusive urban planning.

5.0

Conclusion

While EV lithium-ion batteries (LIBs) are often marketed as a sustainable alternative to internal combustion engine vehicles, a deeper examination of their lifecycle—from mining to disposal—reveals significant environmental and social challenges. The extraction of key materials such as lithium, cobalt, and nickel demands vast amounts of energy, water, and land, contributing to deforestation, pollution, and human rights concerns in mining regions.

An effective EV battery recycling process will safely treat and convert all components, only when all other uses have been exhausted, to reusable material in the same or equivalent industrial uses. This process avoids the use of intense hazardous chemicals, battery burning, and adverse environmental impacts, especially toxic air emissions and hazardous waste byproducts.[50]

However, despite advancements in battery recycling, the current infrastructure remains inadequate to process the growing volume of end-of-life EV batteries. Many LIBs still end up in landfills or are exported for recycling, raising concerns about hazardous waste management. Additionally, as battery technology evolves, LIBs may be replaced by alternatives such as sodium-ion or solid-state batteries, further complicating long-term sustainability efforts.

To truly achieve sustainability, a holistic approach is needed—one that prioritises reducing vehicle dependency, improving public transport systems, and investing in battery technologies with lower environmental and ethical costs. Without addressing these systemic issues, the widespread adoption of EV LIBs risks shifting environmental burdens rather than eliminating them.

[50] GAIA 2025. Questions & Answers: Electric Vehicle Battery Recycling. www.no-burn.org/batteries/#ev

PULAU PINANG

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