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Vehicle Dismantling/Recycling Survey in Response to the Transformation of the Automobile Industry in ASEAN

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List of Abbreviations

AATF	authorised automotive treatment facility
AMS	ASEAN Member State(s)
ASEAN	Association of Southeast Asian Nations
ASR	automotive shredder residue
BEV	battery electric vehicle
BPKB	*buku pemilik kendaraan bermotor* (vehicle registration book)
CAGR	compound annual growth rate
CFC	chlorofluorocarbon
COE	certificate of entitlement
DENR	Department of Environment and Natural Resources, Philippines
DIW	Department of Industrial Works, Thailand
DLT	Department of Land Transport, Thailand
ELV	end-of-life vehicle
EMB	Environmental Management Bureau, Philippines
EPR	extended producer responsibility
ERIA	Economic Research Institute for ASEAN and East Asia
EV	electric vehicle
FCEV	fuel cell electric vehicle
GDP	gross domestic product
HEV	hybrid electric vehicle
HFC	hydrofluorocarbon
ICE	internal combustion engine
JICA	Japan International Cooperation Agency
LTA	Land Transport Authority, Singapore
LTO	Land Transportation Office, Philippines
MAARA	Malaysia Automotive Recyclers Association
MARii	Malaysia Automotive Robotics and IoT Institute
MITI	Ministry of Investment, Trade and Industry, Malaysia

MONRE	Ministry of Natural Resources and Environment, Viet Nam
MS	Malaysian Standard
NEA	National Environment Agency, Singapore
OEM	original equipment manufacturer
OR/CR	official receipt of registration/certificate of registration
PHEV	plug-in hybrid electric vehicle
SAMSAT	*Sistem Administrasi Satu Atap* (One-stop Integrated Administration System)
SMEs	small and medium-sized enterprises
STNK	*surat tanda nomor kendaraan* (vehicle registration number)
SUV	sport utility vehicle
UKM	Universiti Kebangsaan Malaysia
VQS	Vehicle Quota System

Executive Summary

This report is the follow up to *Vehicle Recycling in the ASEAN and other Asian Countries,* which was published in 2018 by the Economic Research Institute for ERIA and East Asia (ERIA). Since the previous survey, changes in the end-of-life vehicle (ELV) industry in each ASEAN Member State (AMS) have become apparent with the increasing number of next-generation vehicles such as electric vehicles (EV), highlighting a growing need to address ELV disposal. Against this background, this survey was conducted with the aim of identifying challenges related to ELV recycling in AMS, focussing on how to develop the circular use of minerals used in ELV, especially EV.

The study was conducted from June 2024 to March 2025 by literature survey, field surveys, and expert meetings, focussing on six AMS – Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. The ERIA and KPMG study team collected and examined documents such as articles, government reports, and news on ELV recycling in ASEAN. It also conducted field surveys in Malaysia, Thailand, and Viet Nam from September to October 2024. The ERIA study team also conducted a field survey in the Philippines in December 2024. Experts provided advice, suggestions, and related information to the study team to formulate the report.

AMS are facing several challenges in ELV recycling. Upstream, the number of cars is increasing, with EV and hybrid electric vehicles (HEV) becoming popular in AMS. This is causing an increase of ELV and will make their recycling challenges more serious in the near future.

Informal sector recycling is one of the common challenges in AMS; another is the development of laws and regulations for ELV and the associated ecosystem. Due to the absence of laws and regulations, the ELV flow and responsibilities of ELV industry stakeholders are unclear, and there is a lack of guidance on disposal methods and recycling procedures. Improper processes also lead to environmental pollution and health risks for workers.

The ERIA study team and experts created eight recommendations. The details are as follows.

Recommendation 1	All AMS should establish legislation or systems on appropriate ELV dismantling and recycling in consideration of their own national circumstances in terms of the economy and capability.

Some AMS are currently pursuing different approaches to improve ELV dismantling and recycling. Malaysia has developed standards for ELV dismantling/recycling, and Viet Nam has established the Extended Producer Responsibility (EPR) Act. The Philippines is focussing on the dismantling and recycling of its public transport vehicles and implementing regulations for their proper recycling. Thailand began a consideration process on the development of ELV-specific legislation through a technical support project of the Japan International Cooperation Agency (JICA).

The appropriate approach depends on national circumstances, including the economic situation, capability, current situation, and pathway of the ELV dismantling/recycling

industry, as well as surrounding industries such as steel and smelting. It is important to share experiences amongst AMS as well.

Recommendation 2	Vehicle owners should be encouraged to replace old cars with poor exhaust systems with new ones with good exhaust systems. Strict implementation of inspections is thus necessary to secure the performance of exhaust systems and the safety of the vehicles on road. Setting a maximum age limit for passenger vehicles could also be considered.

Some experts and many interviewees in the field surveys highlighted the importance of changing the mind-sets of stakeholders, including car owners, about ELV. Many people believe in owning vehicles for a long time, beyond the rational period to maintain their safety or efficiency. Encouragement by the government, car manufacturers, and importers is crucial for a mind-set shift. Some experts also pointed out that the continuous use of very old cars with poor exhaust systems causes serious air pollution in AMS.

If periodic car inspections are appropriately implemented, they could help ensure safe driving, adherence to emissions standards, and a constant supply of ELV to the recycling ecosystem. Strict implementation is necessary to prevent car owners from circumventing inspections.

Defining the age limit of vehicles is also important. In some AMS, age limits for commercial vehicles exist, but no AMS has introduced them for private vehicles or passenger cars. In addition, it is important to have a clear definition of the vehicles to be discarded internationally. A clear definition would help avoid the importation of ELV, for which quality control is difficult.

Recommendation 3	Current efforts to develop a licence scheme for recyclers with appropriate measures and facilities (e.g. Malaysia, Philippines, and Viet Nam) should be encouraged and strengthened. Licence schemes should include tracing mechanisms for ELV and materials for recycling, collection and reuse of batteries, and the appropriate disposal of automotive shredder residue (ASR), chlorofluorocarbons (CFC), waste oil, and other waste generated from the dismantling process. Any priority measures for licensed recyclers should also be considered.

Currently, there is little incentive for informal dismantlers/recyclers to formalise, as their business is profitable. The study team visited some informal sector dismantlers during the site visits and observed that ELV were being dismantled manually, and some workers were not using the proper equipment. While some informal dismantlers are cognisant of noise and odour, most do not care about other environmental issues such as ozone depletion. Waste oil is often not collected, penetrates the soil, and produces negative environmental effects. A possible mitigating option is the implementation of pollution control measures over ELV dismantlers through licensing and/or mandatory regulations.

Also, advanced technologies with safety measures to efficiently recycle ELV have not been widely adopted, despite the increasing numbers of ELV as well as EV and EV batteries. To

promote environmentally friendly ELV recycling, licensing and/or regulation mandates for ELV recyclers should be introduced, as implemented in some AMS including Malaysia and the Philippines. Support from international stakeholders with experience in installing and implementing ELV recycling policies is necessary for policy formulation. Cooperation from international organisations may stipulate that AMS must develop licences and regulations as well. In addition, investment and/or support from the government and private sector is necessary for ELV recycling facilities to improve and to update their infrastructure to comply with regulations to obtain licences.

Some experts and interviewees for this survey pointed out that the number of facilities that conduct proper recycling is insufficient in AMS. To increase the number and to maintain profitability for already licensed dismantlers and recyclers, the priority allocation of specific ELV (e.g. accident-damaged cars from insurance companies and public transport vehicles) to them could occur.

Recommendation 4	For second-hand parts, quality guidance and test measures for reuse, repurpose, and refurbishment should be established. Especially for used EV batteries, a battery passport system should be established for proper management.

Most ELV dismantlers take used parts to sell them as second-hand parts for car maintenance shops or to car owners. However, in many cases, the quality of these parts is not guaranteed. Malaysia has developed Malaysian Standards to provide requirements for the reuse, repair, remanufacture, and recycling activities of vehicle parts and components to guide the appropriate processes, installation of equipment, and reduction of environmental impacts. For other AMS, standardisation could start from revising the classification of hazardous waste, as a second-hand vehicle should immediately be regarded as hazardous waste. AMS should also encourage collaboration to establish common standards and regional rules for ELV recycling, which would contribute to advancing recycling industries by assigning different roles and sharing responsibilities, as well as increasing the tradability of recycling materials amongst AMS.

EV are becoming more popular in AMS. To reuse and repurpose EV batteries, testing and quality guarantees are important. In the expert meetings, one expert highlighted the importance of standardising the testing of used EV batteries and conducting collaborative associated research amongst AMS. EV battery inspection should be promoted across the region because the continued use of damaged/degraded batteries is dangerous. In another expert meeting, an expert highlighted the importance of research and development to improve the detection of damaged/degraded battery cells from battery packs to avoid risks of failure and to establish a standard of testing of used EV batteries. Such research and development should be conducted collaboratively amongst AMS.

The European Union installed the Battery Passport system to track the status of batteries from the start of their use until the end of their lives. This system also requires information on the material of the batteries, manufacturer, and manufacturing place, as the recycling process and recovery rate will be different for each type of material. The standardisation of this system amongst AMS will serve as reference to increase traceability.

Recommendation 5	Capacity building regarding ELV in central governments and local governments is necessary.

Capacity building of knowledge about environmentally friendly ELV processing is necessary in the ASEAN region. Training programmes supported by non-AMS and/or donors are recommended to further leverage available knowledge and experiences accumulated in those countries (e.g. Malaysian automobile companies participated in a training programme in Japan provided by JICA, and the Government of Thailand is currently working with JICA to prepare a legal scheme for ELV recycling).

In addition, dedicated personnel and teams should be organised to improve public awareness on recycling measures and related policy updates through information sharing or any knowledge platform. Detailed manuals, procedures, and guidelines should become more accessible as well.

Closer collaboration amongst the central government, local governments, and the private sector should be strengthened. Recycling activities involve the informal sector, and central governments should maintain dialogue with such players through local governments and civil society organisations. Additionally, closer communication or recycling partnerships amongst AMS should be considered to share each country's strengths and solutions to key challenges. This will contribute to fostering a collective approach to improve the ELV recycling industry in the entire ASEAN region, as well as liquidity in recycled materials and critical minerals from batteries.

Recommendation 6	Non-AMS should support AMS efforts to establish legislation or systems on appropriate ELV dismantling and recycling.

While an appropriate approach to improve ELV dismantling and recycling depends on each AMS's circumstances, support from non-AMS by sharing their lessons learned with AMS could provide a pathway for ELV legislation or systems. For example, Thailand started the consideration process for development of ELV-specific legislation through a technical support project from JICA.

Surrounding systems such as car inspections, financial incentives to replace old cars, dismantling/recycling standards, and guidelines for testing used automotive parts before sale can help AMS implement ELV legislation or systems effectively and smoothly. As an example, in Japan, the government and a recyclers association developed guidelines for testing used automotive parts.

Recommendation 7	Non-AMS should support private sector efforts on transferring advanced technologies for ELV dismantling/recycling to local partners in AMS as well as their initiatives to establish an ELV circularity ecosystem between ASEAN and non-AMS.

Capacity building of knowledge about environmentally friendly ELV processing and practical methods is necessary for ELV dismantlers/recyclers. Training programmes by international stakeholders would be a way to achieve this.

The need for recycled materials is increasing as the world transitions towards a circular economy. The governments of non-AMS should provide opportunities for their ELV

dismantlers/recyclers to support their counterparts in AMS. For example, Tsuruoka was motivated to join the JICA project to provide advanced ELV dismantling and recycling technology to a local recycler in the Philippines (i.e. En Tsumugi), seeing the potential of that country as a supplier of metal scrap from ELV. This initiative not only succeeded in technological transfer but also contributed to an ELV recycling industry ecosystem.

When transferring advanced technologies, it is crucial to conduct economic feasibility studies. In particular, in the case of archipelagic AMS, logistics costs are key to selecting appropriate technologies.

Recommendation 8	It is desirable for non-AMS to collaborate with AMS to establish some standards for recycled materials to increase the international circularity of ELV-relevant materials through analysis of the cost and capacity of material recycling in each country and to conduct research on battery level testing for reuse and safety.

The need for recycled materials such as metals, non-metals, and plastics is increasing due to the worldwide transition towards a circular economy. Securing the quality of recycled materials domestically and establishing international standards within ASEAN and its partner countries is important.

Some experts and some interviewees in the field surveys pointed out the importance of analysing the cost and capacity of material recycling in each country and identifying which countries and materials are most efficiently recycled in ASEAN. For example, lithium-ion batteries in EV can be recycled through hydrometallurgy. However, for hydrometallurgy, many used batteries must be collected to make it economically viable. Not all AMS should have hydrometallurgy battery recycling facilities, but sharing the role of recycling and establishing a value chain is important amongst AMS.

An expert of this research highlighted the importance of establishing not only domestic but also international value chains for EV batteries amongst AMS, as EV batteries contain valuable resources and can contribute to the circular economy. This aligns with the ASEAN Leaders' Declaration, which encourages the harmonisation of regional standards for the EV ecosystem based on international standards to enhance cross-border mobility. An expert also suggested the importance of considering the relationship between ELV recycling and decarbonisation as a long-term issue.

Chapter 1
Background, Objective, and Method of the Study

In November 2018, the Economic Research Institute for ASEAN and East Asia (ERIA) published a report, *Vehicle Recycling in the ASEAN and Other Asian Countries* (Kojima, 2018), which outlined the challenges of vehicle recycling in the ASEAN region. Based on the identified issues, the report noted several policy recommendations.

Yet the situation regarding end-of-life vehicle (ELV) recycling has not improved since the report's publication. Jamaluddin et al. (2022) pointed out that Indonesia, Malaysia, and Thailand – the major automotive production bases in South-east Asia – have no formal ELV recycling policies. Additionally, data show the rapid expansion of the electric vehicle (EV) market – specifically battery EV (BEV) and plug-in hybrid EV (PHEV) – in the ASEAN region. This expansion of EV, leading to greater accumulation of ELV, is thus presenting an additional environmental risk.

The improvement of ELV recycling in ASEAN has become an even more crucial issue; as a result, ERIA decided to conduct a new research project, sponsored by the Government of Japan, Ministry of the Environment. The project has identified the challenges of and possible measures for ELV recycling in ASEAN, focussing on how to materialise the circular use of materials in ELV, especially EV. This project has also formulated policy recommendations for both ASEAN Member States (AMS) and non-AMS, such as Japan.

The study was conducted from June 2024 to March 2025 through a literature survey, field surveys, and expert meetings, targeting Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. The ERIA and KPMG study team collected and examined documents such as articles, governmental reports, and various news sources on ELV recycling in ASEAN. It conducted field surveys in Malaysia, Thailand, and Viet Nam from September to October 2024; ERIA study team members also conducted a field survey in the Philippines in December 2024. During expert meetings, experts provided advice, suggestions, and related information to the ERIA and KPMG study team to formulate this report.

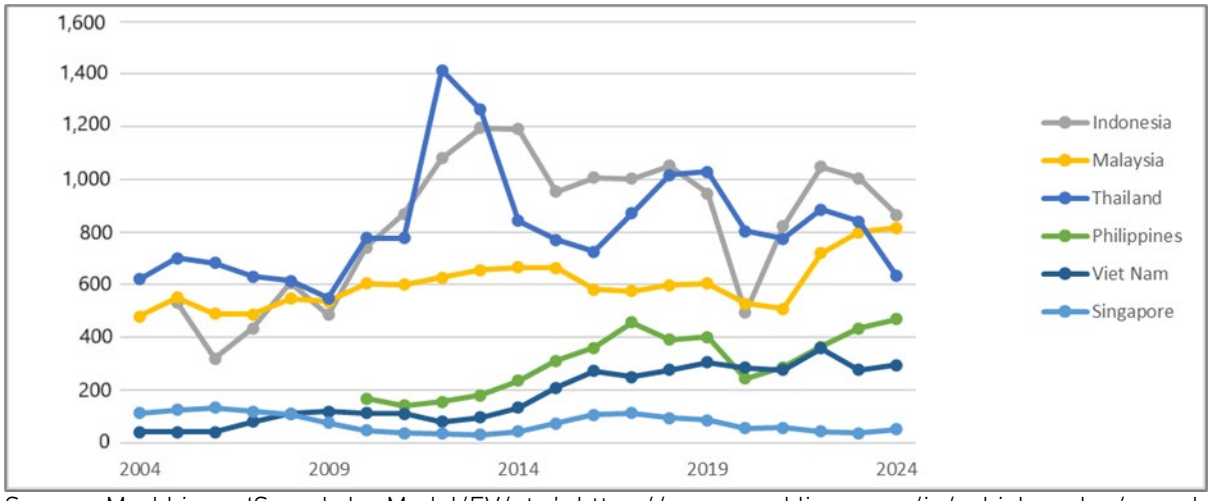
Chapter 2
Current Status of End-of-life Vehicle Recycling in Selected ASEAN Member States

This chapter presents the status of ELV recycling in Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. It focusses on the sales trends of vehicles as well as ELV generation, collection, recycling, and residue disposal.

2.1. Trends in Vehicle Sales

In Indonesia and Thailand, car sales increased until around 2015 then remained stable – except for 2020 and 2021, when they were affected by the COVID-19 pandemic (Figure 2.1). Malaysia's car sales increased significantly after the pandemic; sales in the Philippines and Viet Nam also rose. In Singapore, car sales remained constant.

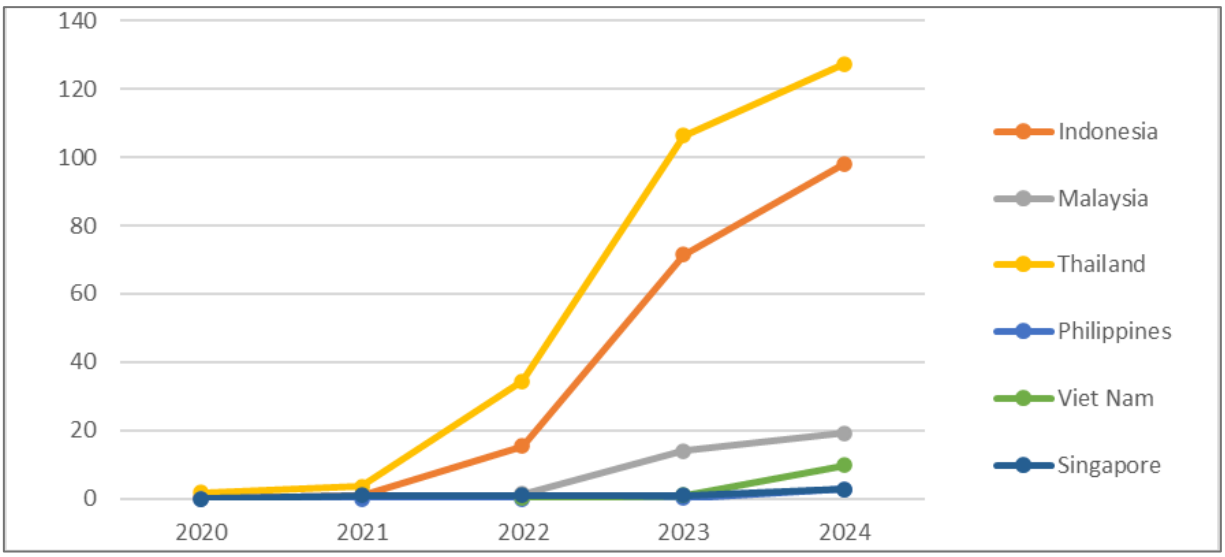
Figure 2.1. Automotive Vehicle Sales in Selected ASEAN Member States, 2004–2024 ('000)



Source: MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search [accessed 11 March 2025].

EV do not yet dominate vehicle sales in AMS, but the number of EV sales is rapidly increasing (Figure 2.2). EV sales in Thailand exceeded 120,000 units in 2024, and EV sales in Indonesia reached about 100,000 units in the same year. Statistics for Viet Nam do not include the sales from VinFast, which announced that it sold over 16,000 EV in November 2024 within Viet Nam, bringing its year-to-date domestic sales volume to over 67,000 units (VinFast, 2023). Actual EV sales in Viet Nam are thus considered much higher than Figure 2.2 indicates.

Figure 2.2. Electric Vehicle Sales in Selected ASEAN Member States, 2020–2024 ('000)



Source: MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search [accessed 11 March 2025].

2.2. End-of-life Vehicle Status

Except in Singapore, cars are unaffordable for many in AMS. Moreover, car owners use their cars as long as possible and sell their old, used cars to those living in rural areas or to exporters. Insurance companies often sell cars damaged in accidents at auction. Thus, on average, ELV generated in AMS are very old; for example, in Viet Nam, many ELV have been used for more than 40 years.

There are various ways to send ELV to dismantlers. Some car owners bring their ELV to dismantlers themselves; in other cases, dismantlers tow ELV to their facilities. Note that some car owners will not sell their cars to dismantlers if the sales price is insufficient to cover the towing cost. As many informal dismantlers in several AMS have failed to invest in environmental protection measures, these dismantlers are able to offer higher prices to car owners than formal dismantlers who pay extra costs for environmental compliance. Therefore, the majority of ELV tend to be sent to the informal sector in AMS. Dismantlers can also buy ELV from car auctions.

Most informal dismantlers disassemble ELV manually, which is not efficient in terms of the number of dismantled cars per day compared with the number dismantled by mechanical equipment such as nibblers. Removal of metallic components from ELV is also done manually, resulting in labour safety issues. The rise of EV is adding more complexity to this issue, as EV contain specialised components – such as high-voltage batteries and unique minerals – which require advanced technologies for safe dismantling and recycling. Although the study team found that the informal sector is learning some EV dismantling methods – often through YouTube videos – there is no guarantee that these new abilities are sufficient for the proper and safe treatment of EV dismantling.

Some formal dismantlers have begun ELV recycling with advanced tools and equipment for environmental pollution prevention in the ASEAN region. One example is Car Medic,

an authorised automotive treatment facility (AATF) in Malaysia, which correctly removes hazardous waste such as petrol, engine and gearbox oil, and chlorofluorocarbon (CFC) and hydrofluorocarbon (HFC) gases through collection machines; stores them in containers; and transfers them to licensed recyclers or waste treatment companies. It has also introduced nibblers, and their employees do wear safety gear for ELV dismantling. Another example is En Tsumugi in the Philippines, which has introduced the technologies and know-how of a Japanese ELV dismantler, Tsuruoka. En Tsumugi has installed gutters, oil/water separation tanks, waste oil and liquid collection equipment, and CFC and HFC gas collection equipment in its dismantling factory. Green Metals in Thailand also introduced similar environmental pollution prevention equipment and advanced dismantling machines.

However, these formal dismantlers are struggling to collect ELV in their respective AMS, because ELV still tend to be sent to the informal sector. To overcome this barrier, these dismantlers are seeking unique ways to collect ELV. Car Medic has contracted with insurance companies and collects ELV from them, while En Tsumugi has contracted with a taxi company to receive end-of-life taxis.

In general, valuable materials removed from dismantled ELV – such as steel and metals – are sold to recyclers. Copper from wire harnesses can be sold as well, while lead batteries also can be sold to recyclers. Yet after the valuable parts are sold, various residue – including hazardous waste – remain. Its disposal varies; the study team found that some informal dismantlers simply spill the oil onto the soil. However, others have installed concrete floors (and roofs) in their facilities; they collect the oil and send it to recyclers or waste treatment companies. The proper disposal of CFC and HFC gases, which have a high greenhouse effect, is a common challenge in AMS. Except for advanced dismantlers such as Car Medic, En Tsumugi and Green Metal, CFC and HFC gases are not collected and are emitted into the atmosphere.

2.2.1. Indonesia

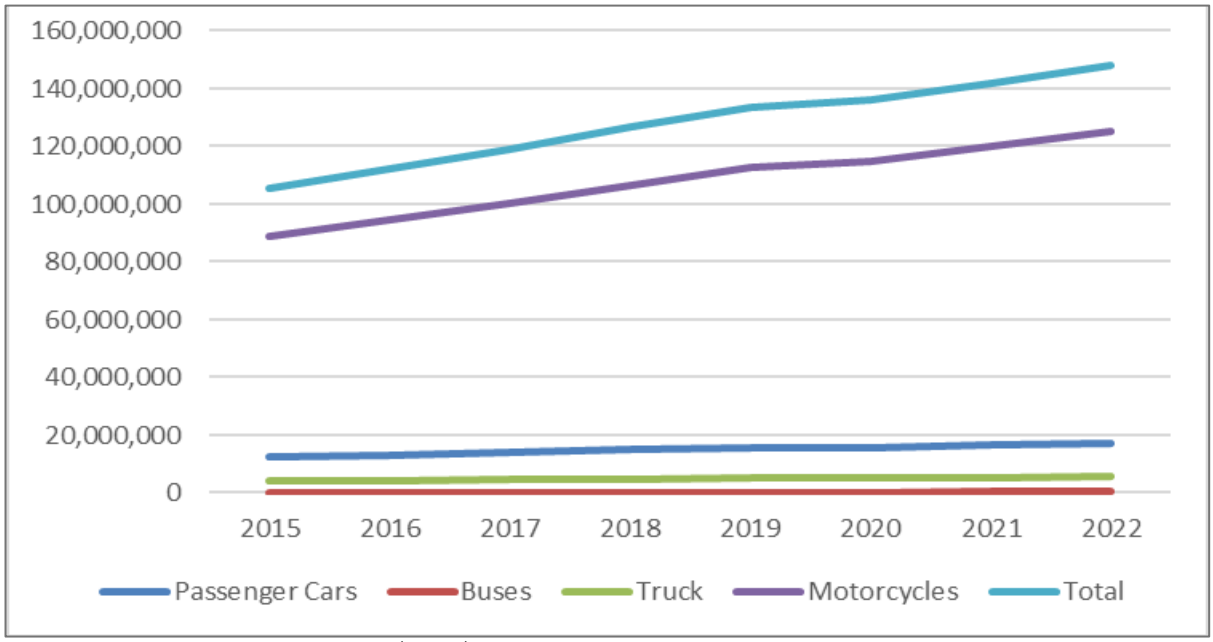
The number of registered motor vehicles – including passenger cars, buses, trucks, and motorcycles – increased from 2015 to 2022 in Indonesia (Table 2.1 and Figure 2.3). The number of passenger cars totalled 17,168,862 and of motorcycles 125,305,332 in 2022, which was an increase of 1.3 times or more from 2015.

Table 2.1. Registered Motor Vehicles by Type, Indonesia, 2015–2022

Vehicle	2015	2016	2017	2018	2019	2020	2021	2022
Passenger Cars	12,304,221	13,142,958	13,968,202	14,830,698	15,592,419	15,797,746	16,413,348	17,168,862
Buses	196,309	204,512	213,359	222,872	231,569	233,261	237,566	243,450
Truck	4,145,857	4,326,731	4,540,902	4,797,254	5,021,888	5,083,405	5,299,361	5,544,173
Motor-cycles	88,656,931	94,531,510	100,200,245	106,657,952	112,771,136	115,023,039	120,042,298	125,305,332
Total	105,303,318	112,205,711	118,922,708	126,508,776	133,617,012	136,137,451	141,992,573	148,261,817

Source: BPS-Statistics Indonesia (2024).

Figure 2.3. Motor Vehicles in Indonesia, 2015–2022



Source: BPS-Statistics Indonesia (2024).

The statistics for ELV by year of manufacture could not be found. However, it is estimated that about 82,000 ELV (i.e. vehicles aged over 10 years) were generated in 2018 in Indonesia (METI, 2019). It is also expected that the number of ELV will be more than 480,000 in the 2030s (METI, 2019).

The EV market in Indonesia is growing rapidly. About 33,600 EV (both two- and four-wheel) were registered in 2022, including 7,600 four-wheel EV. Registration of four-wheel EV numbered 230 in 2021, so the increase from 2021 to 2022 shows significant growth. Regarding two-wheel EV, 1,947 were registered in 2020, rising to 26,000 in 2022 (AC Ventures and Electric Mobility Ecosystem Association, 2023). A Ministry of Industry plan targets the sale of 400,000 four-wheel EV and 750,000 two-wheel EV by 2025 (AC Ventures and Electric Mobility Ecosystem Association, 2023). Ridesharing and logistics companies have been turning to EV as well (Table 2.2).

Table 2.2. Trend of EV Operation in Private Transport Companies, Indonesia

Companies	Initiative
Grab Indonesia	A ridesharing company, Grab started to work on electrification in 2019; it operates 14,000 EV as of July 2023.
Lazada Logistics	A logistics company, it collaborates with Smoot Motor in purchasing and operating EV.
Perusahaan Listrik Negara (PLN)	The national electricity company, PLN, operates 264 EV purchased from PT Gesits Motor Nusantara, a domestic EV manufacturing company and subsidy of Indonesia Battery Corporation and PT Wijaya Karya Industri dan Konstruksi, which is engaged in automotive assembly.
SiCepat Ekspres	A logistics company, it purchased 10,000 Volta electric motorbikes in collaboration with PT Telefast Indonesia Tbk and PT Trans Energy Indonesia.

EV = electric vehicle.
Source: AC Ventures and Electric Mobility Ecosystem Association (2023).

As previously stated, the number of EV sales is increasing rapidly (Table 2.3). The number of four-wheel EV sold was 935 in 2021, growing to 15,437 in 2022 and to 71,503 in 2024. Sales of BEV passenger cars grew from 0.1% in 2021 to 4.8% of car sales in April 2024 (Hall et al., 2024). The Indonesian four-wheel EV market has been attracting global vehicle manufacturing companies such as BYD Auto, Hyundai Motor Company, VinFast, and Wuling Motors. In 2022 and 2023, Hyundai and Wuling models dominated 80% of total BEV sales.[1] Indeed, the government estimated that four-wheel EV sales will reach 50,000 at the end of 2024 (PT Suryacipta Swadaya, 2024).

Table 2.3. Four-wheel Electric Vehicle Sales in Indonesia, 2018–2023

Type	2018	2019	2020	2021	2022	2023
BEV	0	0	86	299	10,327	16,951
HEV	12	0	172	601	5,100	39,107
PHEV	1	4	1	35	10	119
Mild HEV	0	0	0	0	0	15,326
Total	13	4	259	935	15,437	71,503

BEV = battery electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search [accessed 11 March 2025].

[1] MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search [accessed 11 March 2025].

There are several reasons for the significant increase of EV sales in Indonesia. To develop the EV ecosystem in Indonesia, the government issued Presidential Regulation No. 55/2019 in August 2019 concerning the acceleration of EV as part of the overall transition for the transport sector from a fossil fuel base to cleaner ones. It supports an energy-efficient and secure transport sector along with the promotion of clean energy and reduction of greenhouse gases (Kusharsanto, Maninggar, Sucipto, 2024). Under the regulation, the government is providing incentives to EV manufacturing companies. In addition, the Regulation of the Minister of Energy and Mineral Resources No. 3/2023 was promulgated in March 2023 to promote the conversion from two-wheel internal combustion engine (ICE) vehicles to EV. Under this, the government provides stipends to those who exchange their two-wheel ICE vehicles for two-wheel EV.

Moreover, Presidential Regulation No. 79/2023 was enacted to build an EV roadmap focussed on encouraging an EV ecosystem and provision of charging stations. According to experts, the target period for the roadmap is from 2024 to 2030, but it is currently still under development by the Ministry of Energy and Mineral Resources.

The Government of Indonesia has been promoting EV in other ways:

Reducing or exempting taxes for EV manufacturers. As Indonesia is the largest nickel producer in the world, the government is working to increase the domestic production of EV batteries (Okasan Securities, 2024). Currently, it is implementing tax exemption measures for vehicle manufacturing companies that set up EV production factories in Indonesia and have set a goal to utilise 40% of locally sourced EV components by 2026. Manufacturers that meet these requirements can receive a reduction of value-added tax from 11% to 1% and be exempt from the luxury goods tax and customs duty. As of July 2024, Hyundai Motors, Neta Auto Indonesia, and SAIC-GM-Wuling Automotive are all expected to meet these requirements.

Strengthening domestic EV production. Presidential Regulation No. 55/2019 provides a legal umbrella for the development of EV in Indonesia and regulates the use of domestic components for Indonesian EV manufacturers. The government has also established policies to strengthen domestic industries by reducing dependency on imported components. Regulation of the Minister of Industry No. 27/2020 directs manufacturers to use locally produced parts and components in EV; through this regulation, it is expected that 80% of domestic components will be used in EV by 2030.

In 2020, the government banned exporting unprocessed nickel, which led more foreign companies establishing refining facilities and EV production factories in Indonesia. Hyundai Motors, Indonesia Battery Corporation, and LG Energy Solution established HLI Green Power, a joint venture company, to produce EV batteries in Indonesia in July 2021. About 10 EV production projects were developed in Indonesia from June 2021 until the end of 2022, and most of those companies are from China and South Korea (JETRO, 2024a).

The government is promoting domestic EV battery production as well. It established the Indonesia Battery Corporation in March 2021 through the union of four state-owned enterprises – ANTAM (a nickel resources exploitation company), MIND ID (a mining resources company), Pertamina (a petroleum company), and Perusahaan Listrik Negara (the electricity company) – which invested 25% each. They have set a goal to achieve a battery annual production capacity of 140 gigawatt-hours by 2030. They also aim to

produce battery materials, cells, and packs; create original equipment manufacturing (OEM) production of EV and electric motorcycles; promote electric motorcycle battery-swapping system installation; develop OEM production of energy storage systems; and integrate with electricity companies.

Establishing specification for EV industries. From a technical aspect, the government enforced the Regulation of the Minister of Transportation No. 65/2020 to regulate the specifications and overall standards to authorise EV industries and workshops to promote the transition from two-wheel ICE vehicles to EV.

Developing EV infrastructure. The government is also enforcing Regulation of the Minister of Energy and Mineral Resources No. 13/2020 for EV infrastructure development, which contains provisions regarding the technical requirements of non-commercial private electric-charging infrastructure in government offices and households and battery swap and electricity exchange facilities in public areas. In January 2023, the Regulation of the Minister of Energy and Mineral Resources No. 1/2023 was enforced to provide charging station infrastructure for BEV. As of July 2024, the number of EV-charging stations and battery-swapping stations in Indonesia is shown in Tables 2.4 and 2.5.

Table 2.4. Number of EV-charging and Battery-swapping Stations for EV in Indonesia, 2020–2024

Station Type	2020	2021	2022	2023	2024 (July)
EV-charging	93	267	439	932	1,810
Battery-swap	11	266	975	1,772	1,881

EV = electric vehicle.
Source: Authors.

Table 2.5. Number of EV-charging and Battery-swapping Stations by Region in Indonesia

Location	EV-charging	Battery-swapping
DKI Jakarta	393	585
Sumatra	228	232
Banten	150	317
West Jawa	362	390
Central Java and Yogyakarta Special Region	158	72
East Jawa, Bali, and Nusa Tenggara	313	217
Sulawesi, Kalimantan, Maluku, and Papua	206	68
Total	**1,810**	**1,881**

EV = electric vehicle.
Source: Authors.

The primary source of ELV in Indonesia is domestic generation, because the country prohibited the importation of used vehicles and their parts in principle – under Indonesian Ministry of Trade Document No. 1311 dated 29 December 2006 – from 28 February 2007 (Japan Automobile Recycling Promotion Center, 2021). Regarding the importation of used vehicle parts, regulations have been introduced several times. For example, the Regulation of the Minister of Industry No. 14/2016 introduced restricting importation of used parts for direct user and reconditioning companies. It stipulated that second-hand capital goods[2] could be imported by certain companies under specific approval from the Minister of Trade. Second-hand capital goods can be imported within 15 years of production.

The Regulation of the Minister of Trade No. 36/2023, which came into effect on 10 March 2024, expands the range of used goods eligible for importation. The previous regulations only permitted importation of used goods that cannot be sourced domestically as well as goods intended for use in recovery and reconstruction due to disasters. Enforcement of Regulation No. 36/2023 has thus enabled businesses to import residual, scrap, or waste that are not included in the hazardous and toxic waste category for production purposes as well as goods imported for specific purposes.

ELV dismantling and vehicle manufacturing companies are the main collectors of used vehicles in Indonesia. Dismantlers obtain ELV information through SMS, auctions managed by the government or insurance companies, or ELV owners. About 30% of ELV are collected based on SMS communication (METI, 2019). About 80% of ELV are from Jakarta and surrounding areas, and 20% are from Sumatra or Kalimantan. It costs about IDR500,000 to transport an ELV from Jakarta and surrounding areas; about IDR2,000,000 from Java; and about IDR5,000,000 from outside of Java. Such costs are paid by dismantlers. ELV include passenger cars, minibuses, trucks, and buses, with passenger cars constituting the majority. Most are about 20–30 years from production.

The ELV price is calculated based on the selling price of parts and materials, condition of the engine, and dismantlers' fee. The purchase price by vehicle type is shown in Table 2.6.

Table 2.6. End-of-life Car Purchase Prices

(IDR)

Type		Still Operating	Does Not Operate
Produced in Japan	Passenger car	6,000,000–12,000,000	2,000,000–5,000,000
	Commercial car	10,000,000–20,000,000	5,000,000–12,000,000
Produced in Europe	Passenger car	15,000,000–20,000,000	3,000,000–10,000,000
	Commercial car	30,000,000–40,000,000	5,000,000–15,000,000

Source: METI (2019).

[2] The definition of capital goods in the regulation is goods used as capital for business or to produce something, still usable, or to be reconditioned, remanufactured, or refurbished – but not for scrap.

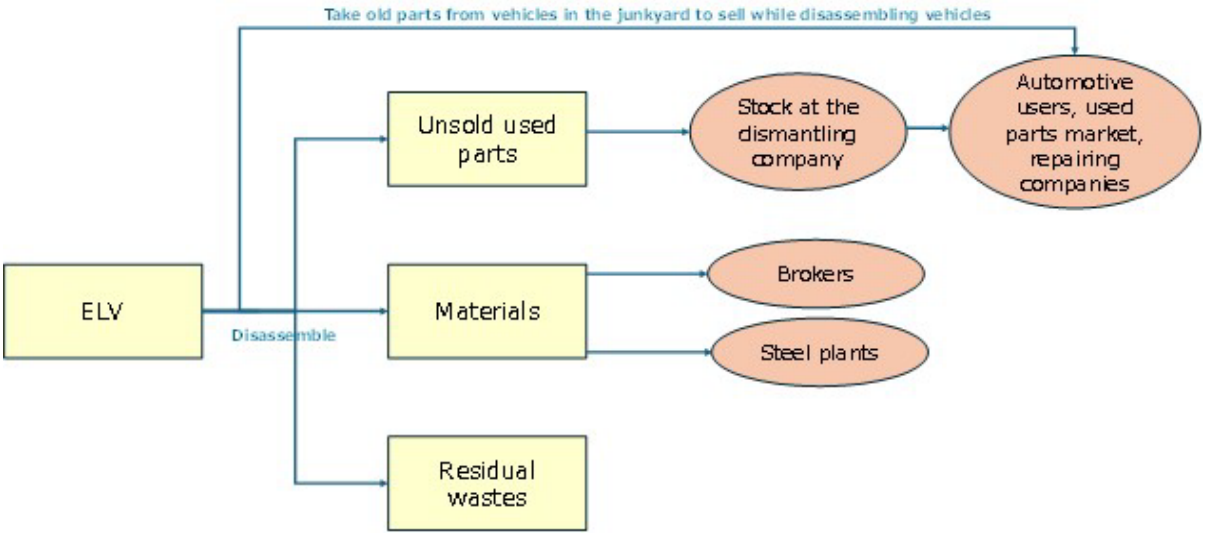
Dismantling companies are usually run by small family businesses. In Indonesia, such businesses are mainly run by the Sunda and Madura ethnic groups. There are about 500 sole proprietors who engage in dismantling ELV in Jakarta and surrounding areas, and about 200 of them are located between Jakarta and Bogor. These dismantling facilities do not have enough equipment due to costs, so dismantlers mostly disassemble vehicle parts manually.

Once a private manufacturer receives an ELV with its disposal certificate, it removes all fluids and oil, reusable parts, and recyclable materials. Recyclable materials, such as large plastic parts, tires, and glass, are separated. The rest of the bodywork is disassembled and cut into parts, which are then reused as much as possible.

Some buy ELV that can no longer be repaired from junkyards and disassemble them (METI, 2019). In general, they first remove tires and rubber from the glass. Then, they remove the petrol, fuel tank, batteries, and engine. Their disassembling practice involves metal picking for wire harnesses through open burning. The car body is hand-cut and sold to steel companies. Materials such as glass and plastic parts are processed separately by informal recyclers.

Figure 2.4 shows the flow of disassembling and recycling ELV in Indonesia.

Figure 2.4. Disassembling and Recycling Process of ELV in Indonesia



ELV = end-of-life vehicle.
Source: Authors based on METI (2019).

ELV are disassembled into parts when buyers for the parts are found or known. The parts are sold to markets or repair companies, and those unsold are kept as stock in junkyards (Figure 2.5). Disassembled parts can also be stocked at the dismantling companies and sold to vehicle owners or repair companies. Other materials are sold to brokers, and steel scraps are sent to steel plants.

Figure 2.5. Junkyard Images, Indonesia

Cars

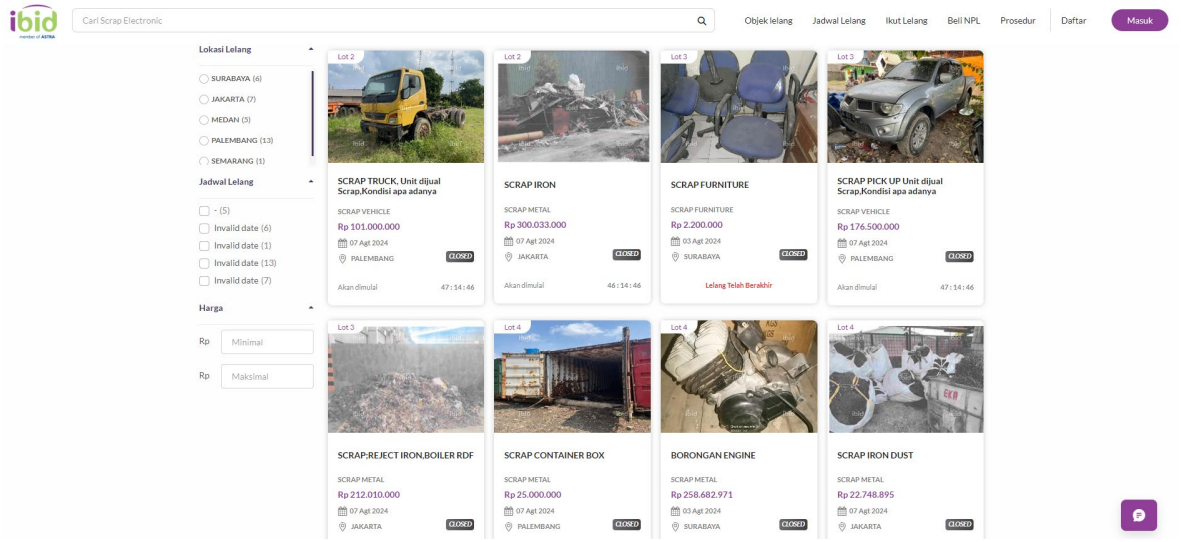
Scraps

Source: METI (2019).

Vehicle parts can also be sold at various markets. A well-known automotive market is Pasar Mobil Kemayoran (Kemayoran Car Market) in Jakarta. Second-hand vehicle shops, used car parts/accessory shops, and repair companies are in this market. They sell both new and old vehicles and parts. Many also have websites to search for spare parts and accessories.

Auction websites are also utilised to sell ELV parts. KPKNL Balikpapan Auction Service (State Assets and Auction Services), under the Ministry of Finance, auctions vehicles and scrap goods. It is responsible for ensuring the effectiveness of governmental spending towards public auction execution and serving as an alternative transaction mechanism (KPKNL, 2021). ELV and their parts can also be sold on private auction websites. One of the most trusted auction houses is IBID, established in 2007 (Figure 2.6). IBID sells used vehicles, used tires, and iron containers. It also auctions heavy vehicles, such as those used for mining, construction, and on plantations as well as their scrap parts. PT Serasi Autoraya, one of the largest transport and logistics companies in Indonesia, operates IBID (PT Serasi Autoraya, 2021). It is a subsidiary of Astra International.

Figure 2.6. Scrap Auction Website, IBID



Source: IBID, https://www.ibid.astra.co.ida/cari-lelang/scrap [accessed 11 March 2025].

Participants must purchase auction numbers for an IBID auction after a IDR5,000,000 deposit is made at the IBID office and their account is registered (PT Serasi Autoraya, 2024). IBID offers information and a description of each good (e.g. the location, deposit for dismantling, and contact person).

Specific material recycling is detailed below.

Scraps. Materials such as scraps of iron, copper, and aluminium that cannot be reused are sold to electric furnace operators or refiners. Scraps are recycled into billets, flat steel, or round bars. Steel scraps are refined in electric furnaces and transformed into flat steel or wire rods to use as vehicle parts. Aluminium materials are refined and transformed into ingots. Some businesses also purchase scraps, engines, and transmissions that failed at inspection from vehicle manufacturing companies.

Oil. Once recycling companies collect waste with oil, they take out oil and incinerate the residue. Collected oil is accumulated at four waste oil recyclers, which includes Pennzoil, an American company, and Agip, an Italian company (EX Research Institute, 2015). These oil recyclers are required to obtain licences from the Ministry of Transportation. Oil is recycled into supplemental fuel for cement manufacturing.

Tires. Recycling tires is mainly conducted by the informal sector, but companies such as Xinxiang Huayin Renewable Energy Equipment have introduced advanced technology to change waste tires into fuel oil (Kojima, 2018). Tires can also be shredded and transformed into materials for rubber products such as shoe soles.

Lead batteries. There are many lead battery recyclers in Indonesia; many are in the informal sector. Lead batteries are regarded as valuable resources, and lead and plastic from them are recycled. Such batteries contain diluted sulphuric acid, and this needs proper treatment for disposal as hazardous waste (i.e. Government Regulation No.101/2014). Some recyclers separate batteries into lead and plastic pieces and fabricate ingots from the dismantled lead.

EV batteries. According to Article 32 of Presidential Regulation No. 55/2019, battery waste from EV must be recycled and/or managed. The EV industry and/or domestic EV components industry that processes the waste must obtain battery waste management licences. The first EV battery-recycling facility, PT Indonesia Puqing Recycling Technology, was established in Sulawesi in 2021. It is a consortium company of Guangdong Brunp Recycling Technology (a recycling company from China), GEM (an EV battery material supplier from China), and PT Indonesia Morowali Industrial Park. The investment ratio is 70% from Guangdong Brunp Recycling Technology, 15% from GEM, and 15% from PT Indonesia Morowali Industrial Park. PT Indonesia Puqing Recycling Technology is expected to process 20,000 tonnes of used EV batteries and to recover 12,000 tonnes of nickel and cobalt, 1,200 tonnes of lithium, 3,400 tonnes of copper, 2,000 tonnes of metals for battery packs, 1,600 tonnes of steel, and 1,000 tonnes of plastics annually (JOGMEC, 2021). Moreover, Attero Recycling, a lithium-ion battery recycling company from India, is constructing an EV battery-recycling facility in Indonesia, which will start operation in 2024.

Unsold parts and materials. These are generally discarded. Parts and materials are processed as shown in Table 2.7. As already noted, oil and rubber can be recycled; however, they are often discarded if the waste amount is not enough for profit.

Table 2.7. Unsold Waste from End-of-life Vehicles

Discarded Parts/Materials	Components	Process
Waste liquid	Oil	Dripping
	Cooling water	Dripping
Broken glass	Glass	Processed as waste
Tires	Rubber	Incinerated
Rubber seals		Incinerated
CFC inside air conditioners	CFC	Released into the atmosphere
Sheets	Urethane	Incinerated

CFC = chlorofluorocarbon, ELV = end-of-life vehicle.
Source: METI (2019).

Halogenated hydrocarbon, sludge, combustible solvents, pigments, metals, and heavy metals (especially arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and zinc), tin compounds, used lead batteries, and oil waste such as sludge oil and waste engine oil from ELV are subject to waste disposal regulations. Recyclable waste, like waste engine oil, should be packed in a tank and transferred to a waste disposal contractor that is registered as a B3 treatment-certified company. However, as disassembling areas are often not covered by concrete, waste oil, waste liquids, and sulphuric acid tend to just leak onto the ground. Vinyl chloride materials in seats and harnesses are also often burnt on the ground.

2.2.2. Malaysia

In 2020, the number of registered passenger cars and commercial vehicles in Malaysia decreased due to the COVID-19 pandemic but recovered in 2022 (Table 2.8).

Table 2.8. New Passenger and Commercial Registered in Malaysia, 2010–2023

Year	Passenger Cars	Commercial Vehicles	Total
2010	543,594	61,562	605,156
2011	535,113	65,010	600,123
2012	552,158	75,575	627,733
2013	576,640	79,104	655,744
2014	588,348	78,139	666,487
2015	591,275	75,402	666,677
2016	514,594	65,491	580,085
2017	514,675	61,950	576,625
2018	533,202	65,512	598,714
2019	550,179	54,108	604,287
2020	480,971	48,543	529,514
2021	452,663	56,248	508,911
2022	641,773	78,885	720,658
2023	719,160	80,571	799,731

Source: MAA, 'Sales and Production Statistics', https://www.maa.org.my/statistics.html

As of December 2023, the Ministry of Transport reported that 10,169,920 passenger vehicles (both two- and four-wheel) were 10 years old or older. In terms of vehicle maintenance and repair, Malaysia had 32,077 workshops as recorded by the Department of Statistics Malaysia in 2019.

The first announcement from the Government of Malaysia on the penetration of EV was the *Low Carbon Mobility Blueprint 2021–2030*. The Ministry of Natural Resources and Environmental Sustainability announced the blueprint in 2020, whose objectives were to reduce the total primary energy supply and energy consumption, encourage fuel expenditure savings, expand industry, and lessen emissions (MEW, 2021). The blueprint focusses on emissions and energy reduction by adopting electric cars, buses, and motorcycles. It is composed of 10 strategies, and each strategy has an action plan. Governmental agencies and government-linked companies are to procure EV and to give incentives to employees who commute on public transport. In addition, the government is working to adopt a massive number of EV to foster the domestic EV manufacturing business. As an example, one action plan outlines a government-led initiative to adopt EV for taxi services by providing incentives (e.g. an income tax exemption) for taxi owners who purchase EV.

In addition, the Ministry of Economy announced the *National Energy Transformation Roadmap* in 2023 (MEC, 2023). It sets to increase the amount of xEV (i.e. BEV, fuel cell EV [FCEV], hybrid EV [HEV], and PHEV) within all kinds of vehicles to up to 20% by 2030, up to 50% by 2040, and up to 80% by 2050.

During the field survey in Malaysia, the study team obtained information that the government is preparing for the next-generation vehicle industry to enhance Malaysia's international competitiveness. At the same time, the government recognises the importance of reducing emissions from land transport, particularly regarding its Paris Agreement obligations; thus, this serves as another reason to foster the EV market, including charging stations. The number of EV charging spots in Malaysia was 2,585 as of June 2024 (JETRO, 2024a).

EV sales increased dramatically in 2023 (Table 2.9), when the government promoted incentives for next-generation vehicles. The government further introduced tax exemptions for EV for companies in 2024, which will be available until at least 2027. According to the Ministry of Investment, Trade and Industry (MITI), having strengthened its semiconductor industry for 50 years, Malaysia possesses the experience and resources necessary to similarly promote its domestic EV manufacturing industry. Indeed, a domestic vehicle manufacturing company, Proton, launched its EV sales in October 2024, and Perodua is planning to launch them in 2025.

Table 2.9. EV Sales in Malaysia, 2022 and 2023

Type	2022	2023
BEV	1,428	7,759
PHEV	0	145
Mild HEV	0	5,204
Total	1,428	13,108

BEV = battery electric vehicle, EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search [accessed 11 March 2025].

The government also recognises the importance of building a battery-recycling ecosystem for greener industry. Although it is still difficult to realise enough profit from EV battery recycling due to the limited number of EV batteries in Malaysia, the country plans to build hydrometallurgy and pyrometallurgy factories in partnership with China and South Korea, according to an expert interview. According to MITI, there are three battery-recycling companies using Korean and Chinese technology in Malaysia. Two are in the Klang Valley in Selangor, and one is in Ipoh in Perak (Mardhiah, 2024).

The study team conducted interviews with MITI, the Malaysia Automotive Robotics and IoT Institute (MARii), and other stakeholders in Malaysia. These revealed that the government is discussing developing EV battery passports, which are digital records of a battery including its composition, manufacturer, and manufacturing place. This system is already in place in China, the European Union, and United States. MITI noted that currently, recycling companies have difficulty tracking the composition of batteries, leading to Malaysia's low recycling rate of 5–10%. MARii is taking up the initiative to develop the

system (Palansamy, 2025).

ELV are generated in Malaysia in the following ways.

From used vehicle/parts dealers. Vehicle owners sell ELV to dealers or at internet auction. There are 2,000–3,000 dealers in Malaysia. Most are members of the Malaysia Automotive Recyclers Association and import used cars and parts to sell. Non-reusable parts are sold to scrappers when steel is in high demand. The market price of scraps is approximately MYR0.80 per kilogram.

Abandonment. The number of abandoned cars in Malaysia is increasing rapidly; 60,000 were abandoned nationwide in 2018 (Daim, 2024). These cars were abandoned by the roadside, in parking lots, and in residential areas, causing threats such as theft and issues related to health and the environment (Figure 2.7).

Figure 2.7. Storage of Abandoned Cars by Kuala Lumpur City Hall

Source: MOE (2021).

The study team visited Universiti Kebangsaan Malaysia (UKM), learning that it had supported the Ampang Jaya Municipal Council in managing its ELV and abandoned vehicles, as Ampang Jaya had many. The council first defined abandoned vehicles[3] and then created an internal workflow regarding ELV deregistration, collection, and recycling in their guidelines, which are available in Malay and online. UKM helped define the legal process of ELV collection and recycling, including such details as when to notify vehicle owners that their vehicles will become ELV and subsequent steps that owners should take to reclaim their vehicles. The legal process has been adopted as local law and implemented since 2023.

In addition, the council established a one-stop centre for managing the disposal of vehicles; owners/citizens merely need to inform it of the location of the vehicle. It works

[3] UKM suggested the following definition for an abandoned vehicle: no valid road tax paid for 1 year, engine unable to start, has flat tire(s), has a broken windshield, car body is scratched, and parts are missing.

with the Road Transport Department to process the vehicle deregistration and for collection (Figure 2.8).

Figure 2.8. Advertisement for One-stop Centre for Abandoned Cars by Ampang Jaya Municipal Council

Source: Majlis Perbandaran Ampang Jaya (Ampang Jaya Municipal Council), 'Train Stop Center Left Behind (Pusat Sehenti Kereta Terbiar)', https://www.mpaj.gov.my/ms/mpaj/pusat-media/pengumuman/pusat-sehenti-kereta-terbiar

The Government of Malaysia launched another initiative, Cash for Clunkers, in 2009. About MYR29 billion was allocated to encourage vehicle owners to officially declare their unused or unwanted vehicles as scrap after deregistering them. Vehicles had to be more than 10 years old, and owners could receive a MYR5,000 rebate when purchasing a new vehicle manufactured by Proton or Perodua. Kualiti Alam, a designated waste treatment company, was tasked with handling the ELV, as it has a licence to handle scheduled waste under Environment Quality (Scheduled Waste) Regulation 2005. It ended up processing roughly 48,000 ELV (Jamaluddin et al., 2022)

The initiative ended in 2011 due to its significant cost and limited impact on reducing the number of old, environmentally harmful vehicles on the road. While the scheme did help promote the purchase of new vehicles and ensured the proper disposal of ELV, the initiative faced challenges in reaching a broader segment of vehicle owners and achieving widespread participation since only Proton and Perodua were targets for rebate. When

the study team conducted interviews with Malaysian automotive stakeholders, they pointed out that the programme unintentionally made people believe that vehicles over 10 years old had to be scrapped.

Insurance companies also collect vehicles damaged in accidents. The collected cars are repaired and sold as second-hand or disassembled to sell parts. In line with Malaysian Standard (MS) 2726:2024, insurance companies play a crucial role in appointing a third party to assess whether a damaged vehicle is beyond economic repair (i.e. so damaged it would cost more to repair it than to replace it) or an actual total loss (i.e. a loss that occurs when insured property is destroyed or damaged to such an extent that it cannot be recovered nor repaired for further use). This assessment is necessary to determine whether repairing the vehicle is financially viable or if it should be written off. The third party, typically an assessor or a certified expert, ensures that the decision is based on standardised guidelines and promotes fairness and consistency in the insurance claims process.

In March 2021, AATF were established under the Department of Environment as a licensing scheme for the processing and disposal of ELV with the aims of avoiding environmental pollution and enabling the recovery of recyclable elements (Box 2.1).

Box 2.1. Translated Definition of Authorised Automotive Treatment Facilities

Authorised automotive treatment facilities (AATF) are those that will carry out the dismantling of components, especially that contain scheduled waste (hazardous waste) from vehicles that are deregistered by the Ministry of Transport. The components will be separated for reuse, recycling, or recovery and sent to final disposal. Facilities are licensed by the Department of Environment under Section 18, Environmental Quality Act 1974.

This sustainable initiative was introduced by the Department of Environment in 2021 to deal with the issue of abandoned vehicles that are getting more and more public attention because they are seen as having the potential to cause environmental pollution if not managed well.

Source: MNRES (2021).

In December 2024, there were two AATF (Table 2.10). MARii noted that 15 companies are in the pipeline for the AATF licensing process. According to MARii, all vehicles involved in accidents must be sent to an AATF as outlined in MS 2726:2024 and MS 2729:2023.

Table 2.10. List of Authorised Automotive Treatment Facilities

Company	Address	Licence No.	Status
Car Medic	No. 1A, Jalan P4/7, Bandar Teknologi Kajang, 43500, Semenyih, Selangor	006848	Licensed
Jaring Metal Industries	No,7 & 9, Jalan Sungai Kayu Ara 32/37, Taman Perindustrian Berjaya, Seksyen 32, 40460 Shah Alan, Selangor	006860	Licensed

Source: MNRES (2021).

The study team visited Car Medic, an AATF (Figure 2.9). According to Car Medic, it purchases used cars and those involved in accidents (i.e. actual total losses) from insurance companies and private owners. Car Medic receives many vehicles from remote areas as well. The purchase price depends on the condition, size, manufacturer, and towing cost. Car Medic covers the towing fee and tries to adjust the cost borne by private owners. Its purchase price is lower than that of informal dismantlers; thus, there is competition. Car Medic advertises through SMS, noting that it is a licensed facility for scrapping and recycling vehicles in an environmentally friendly way to differentiate itself.

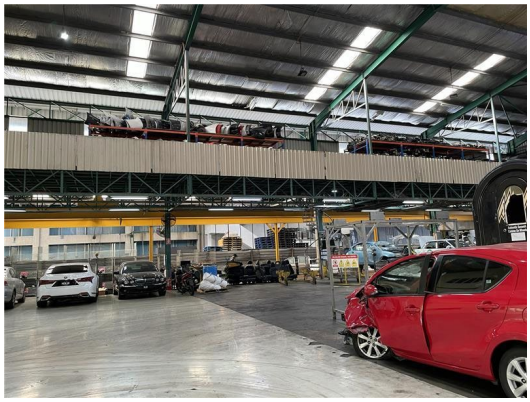
Figure 2.9. Authorised Automotive Treatment Facility Images from Car Medic

Car Medic

Crashed Car Sent from Insurance Company

Vehicle and Parts Storage

Inside the Facility



Source: Authors.

In addition, informal dismantlers often import ELV (Figure 2.10). One informal dismantler that the study team visited imports used parts and half-cut vehicles – about 300 units per year – from Japan or the United States and dismantles them and sells the parts. It inspects the half-cut vehicles before purchasing them. The ratio of half-cut HEV is about 1 in 100 units, with the rest being ICE. Half-cut HEV arrive without batteries, as the batteries need careful treatment. The used parts are brought in by truck and stored under a roof or in the yard. Another used parts dealer imports parts that were already dismantled in Japan (in Oita Prefecture and Kochi Prefecture), totalling about 60 units per month.

Another ELV dismantling company that the study team visited collects ELV from private

owners. Its staff members visit car owners to create contracts and to receive the ELV, which are still registered. The dismantling company raises 50% of its profit from dismantling, with the other 50% from vehicle maintenance and selling e-waste. It receives or buys 15–50 ELV per month. The minimum price of an ELV is about MYR1,000. The company advertises on Google and Instagram, and many customers contact the dismantling company by SMS or by direct visit.

Figure 2.10. Informal Sector Dismantler and Used Part Seller Images, Malaysia

Inside Informal Sector Dismantler 1

Trucks with Used Parts

Outside Informal Sector Dismantler 1

Towing, Informal Sector Dismantler 2

ELV Storage, Informal Sector Dismantler 2

Used Parts Seller

Figure 2.10. *Continued*

Informal Dismantling Company

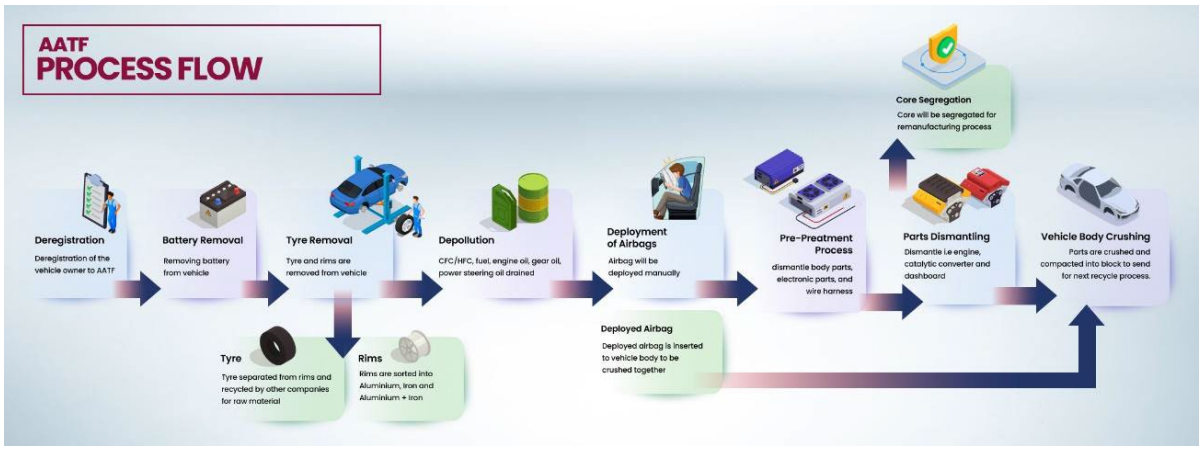
ELV Storage

Source: Authors.

Another ELV dismantling company that the study team visited purchases ELV from individuals, maintenance companies, and auctions that the Road Transport Department runs. Private auctions are more competitive than Road Transport Department auctions. These check brands and the condition of ELV and fixes the purchase price, which is MYR500–MYR10,000. Imported brands (e.g. Toyota and Honda) are more expensive than domestic brands (e.g. Proton and Perodua EV). It mentioned that the Honda City and Accord and Toyota Hilux are more expensive than light vehicles such as the Daihatsu Mira.

AATF are required to adhere to regulations of the recycling process for ELV set by the Department of Environment, Road Transport Department, and Ministry of Transport. AATF are expected to undertake the process shown in Figure 2.11.

Figure 2.11. Authorised Automotive Treatment Facility Process



Source: MARii, 'Authorised Automotive Treatment Facility (AATF) Application', https://marii.my/authorised-automotive-treatment-facility-aatf-application/

The following process was described by Car Medic: (i) deregister the vehicle from the Road Transport Department; (ii) conduct an inspection, label the vehicle, and register the

record in the in-house management system; (iii) remove hazardous waste such as petrol, engine oil, and gearbox oil at a depollution station using a tank-drilling device and oil funnel; (iv) remove brake oil, power steering oil, and windshield washer fluid, and store them in designated containers; (v) remove CFC and HFC gases using the air-conditioner system oil exchanger, place in a machine to ensure that no gases are released into the environment, and store them in the scheduled waste container; (vi) remove batteries; (vii) remove wheels, and separate them into tires and wheel rims by using pyrolysis equipment; (viii) remove airbags manually; (ix) remove body parts, electronic parts, wire harnesses, engine catalytic converter, and dashboard using a nibbler; (x) crush vehicle body using the nibbler; and (xi) send engine to another workspace to separate the oil and material (Figure 2.12).

There are about 30 staff members working in dismantling areas, and about 6 in management. All are skilled.

Waste liquid at the first dismantling area is collected under the floor and filtered three times. The under-floor filtration system is inspected once per year. The filtered liquid is released into the environment, and the sludge collected in the oil trap is sent to licensed collectors. The remaining oil in the vehicle is collected in the next dismantling area. Engines and plastic parts and other raw materials are sold to recycling companies, and the selling price depends on demand. Car Medic does not own metal shredders; however, some metal scrap companies own shredders. Car Medic supplies ferrous materials, such as car bodies, to such metal scrap companies.

For the final dismantling process, nibblers are used to remove body parts, electronic parts, wire harnesses, the engine catalytic converter, and dashboard. Cameras are set in the operation room and in front of the nibbler to monitor the operator and process through an in-house monitoring system. Managers and workers in the office can check it through a smartphone app. Waste and recyclable materials are sorted, and recyclable materials are sent to recycling companies while others are sent to landfills.

Car Medic was chosen as a Toyota Global 100 Dismantler in its Sustainability Data Book 2021, which means that it uses good practices for dealing with and recycling vehicle waste (Toyota, 2021).

Figure 2.12. End-of-life Vehicle Recycling Process as Described by Car Medic, Malaysia

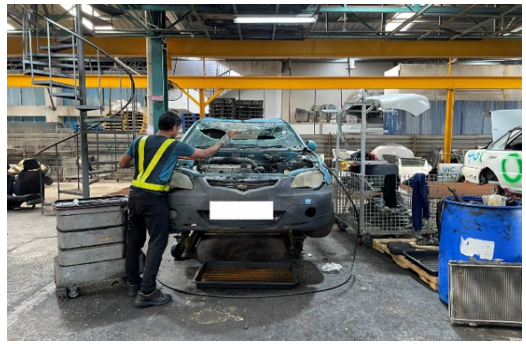
Entrance to Inspection Area

First Dismantling Area

Inside Check

Remove Parts and Waste Liquid

Leaked Liquid Filtration
(3-step system, left to right)



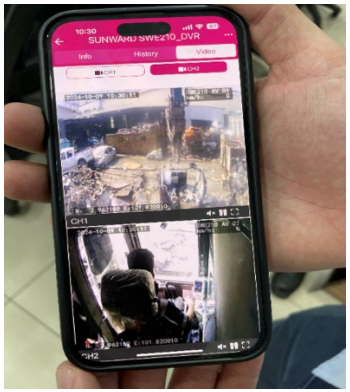
Second Dismantling Area

Figure 2.12. *Continued*

Final Dismantling Area

Dismantling Using Nibbler

Crushing Body



Dismantling Process Monitoring System

Parts Storage 1

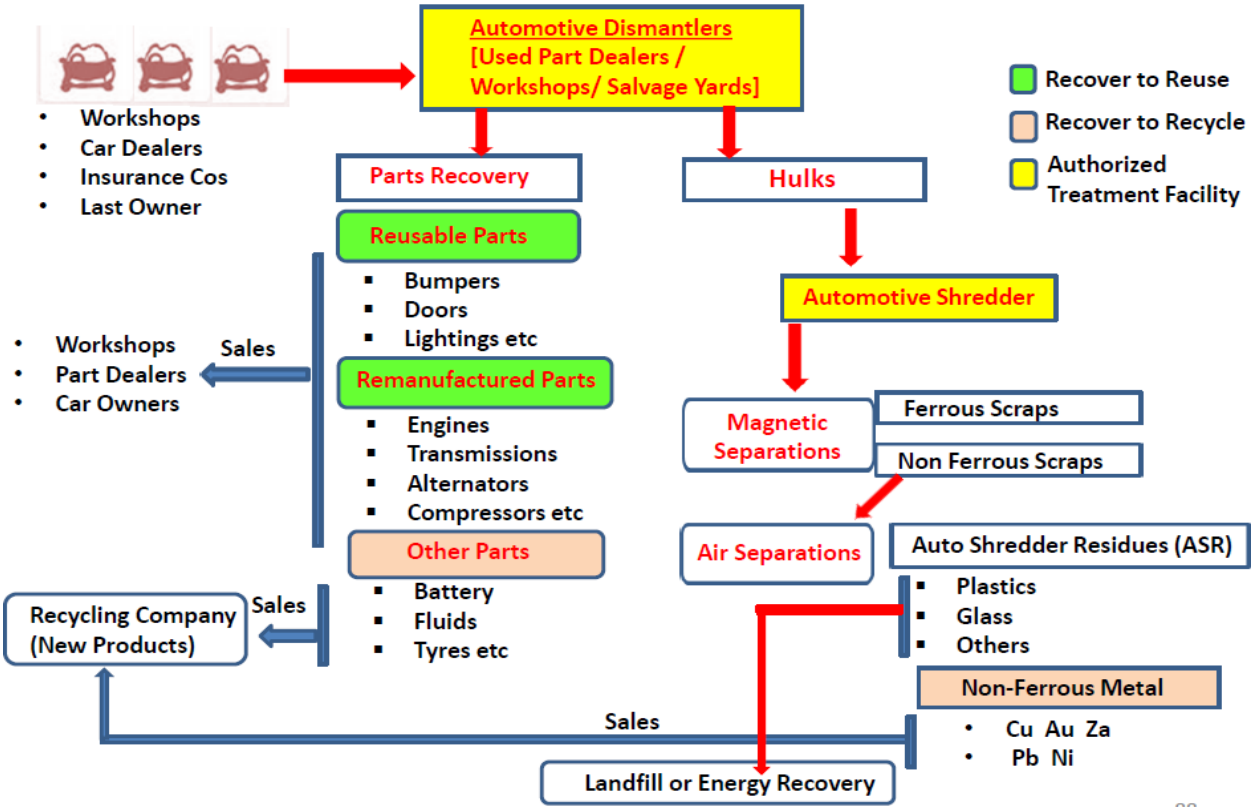
Parts Storage 2

Source: Authors.

The floor of an AATF should be covered with concrete to prevent pollution into the ground. It should also own specialised vehicle recycling equipment to enable the processing of a large amount of vehicles. It must acquire MS 2697:2018 certification as well.

Figure 2.13 illustrates the recycling process for ELV in Malaysia. Note that companies that own shredders sell the ELV scrap to smelting companies.

Figure 2.13. End-of-life Vehicle Recycling Process, Malaysia



Au = gold, ELV = end-of-life vehicle, Cu = copper, Ni = nickel, Pb = lead, Zn = zinc.
Source: Sulaiman et al. (2023).

In the informal sector, ELV are mainly dismantled manually. Gas-cutting equipment is used for cutting the body apart. It takes 2–3 hours to dismantle a car; five to six cars are processed per day. One informal sector facility that the study team visited has concrete floors and roofs (Figure 2.14); however, there are no actual regulations for dismantling facilities in place. It had about 10 back-office workers and about 25 on-site workers.

Figure 2.14. Dismantling ELV, Informal Sector, Malaysia

Informal Dismantler 1

Removing Seats

Wire Harnesses

Dismantled ELV

ELV Body

Informal Dismantler 2

Source: Authors.

Informal dismantlers sell reusable and recyclable materials. They segregate ELV into engines, plastics, and other parts and waste. One informal dismantler that the study team visited exports parts to the United Arab Emirates and Pakistan. It also sells half-cut vehicles to African countries as well as to Pakistan. Parts can also be sold to domestic buyers and individual walk-in customers, but demand is falling. Engines and engine boxes are sold the most. Informal dismantlers make profits if they purchase ELV at MYR1,000 or succeed in selling the parts at MYR4,000 or more.

One informal sector dismantler does not dismantle HEV but sells them as half-cut vehicles. Another dismantler that the study team visited was trying to dismantle HEV via

the instructions of friends and instruction manuals of safety measures.

Through an interview with an informal sector dismantler, it was noted that many parts are reused/recycled. Wire harnesses are sold to domestic scrapping companies; unsold engines are disassembled into steel and aluminium and sold; car bodies are sent to smelting companies; oil is collected and handed over to collecting companies; seat belts are given away for free; and HEV batteries that are still usable are sold, and non-usable ones are sold to recyclers.

An AATF must be certificated and licensed by the Department of Environment to handle scheduled waste. The floor in Car Medic is covered with concrete for preventing pollution seepage, and the scheduled waste storage room has a specific design (Figure 2.15).

Figure 2.15. Scheduled Waste Storage Images, Authorised Automotive Treatment Facility, Malaysia

Scheduled Waste Storage

Sorted Lithium Batteries

Hazardous Liquids

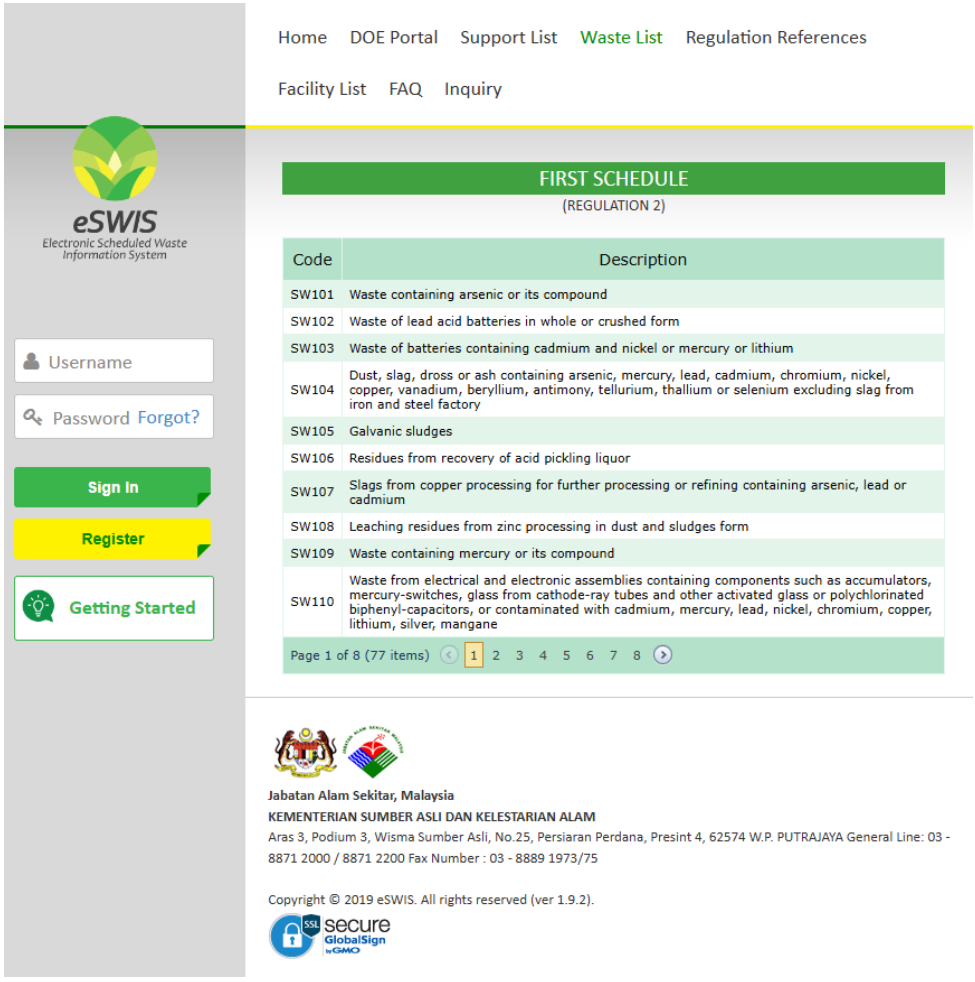
Sorted Waste

Source: Authors.

Via an AATF, residue is supposed to be disposed of by designated companies. Waste oil, waste batteries, and waste catalysts, which are designated as scheduled waste, are handed to such companies, which transport, store, process, and dispose of them. ELV dismantlers, waste transport companies, and waste-processing companies need to have relevant licences for their incinerator facilities, off-site facilities, off-site treatment facilities, secured landfills, transporters, and off-site recovery.

The list of scheduled waste is announced in the Electronic Scheduled Waste Information System (Figure 2.16).

Figure 2.16. Scheduled Waste List in Malaysia



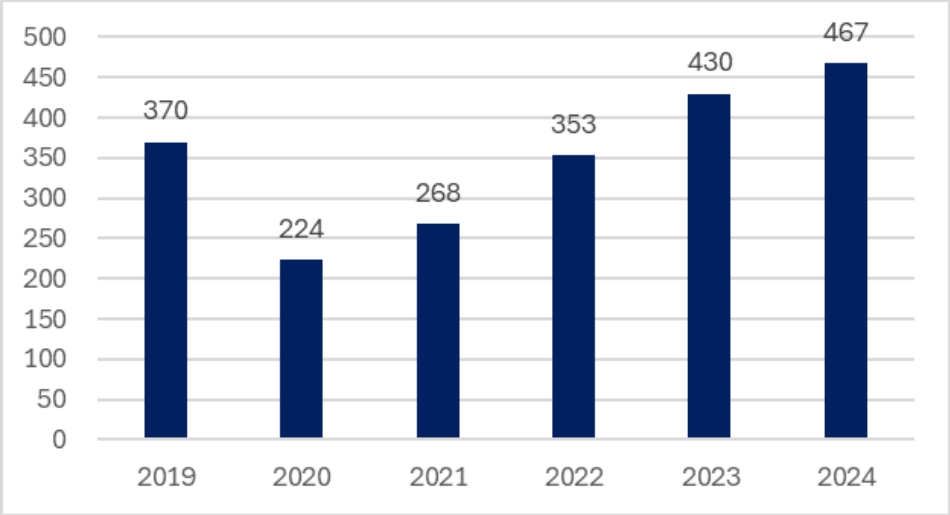
Source: eSWIS, First Schedule, https://eswis.doe.gov.my/wasteList.aspx

Scheduled waste is tracked by this system. AATF are responsible for the traceability of scheduled waste and must record input and output of the waste to the Electronic Scheduled Waste Information System every day. AATF also cannot store the waste in their facilities for more than 180 days.

2.2.3. Philippines

According to the Chamber of Automotive Manufacturers of the Philippines and Association of Vehicle Importers and Distributors, car sales in the Philippines fell due to the pandemic but have been recovering (Figure 2.17).

Figure 2.17. Vehicles Sold in the Philippines, 2019–2024
('000)

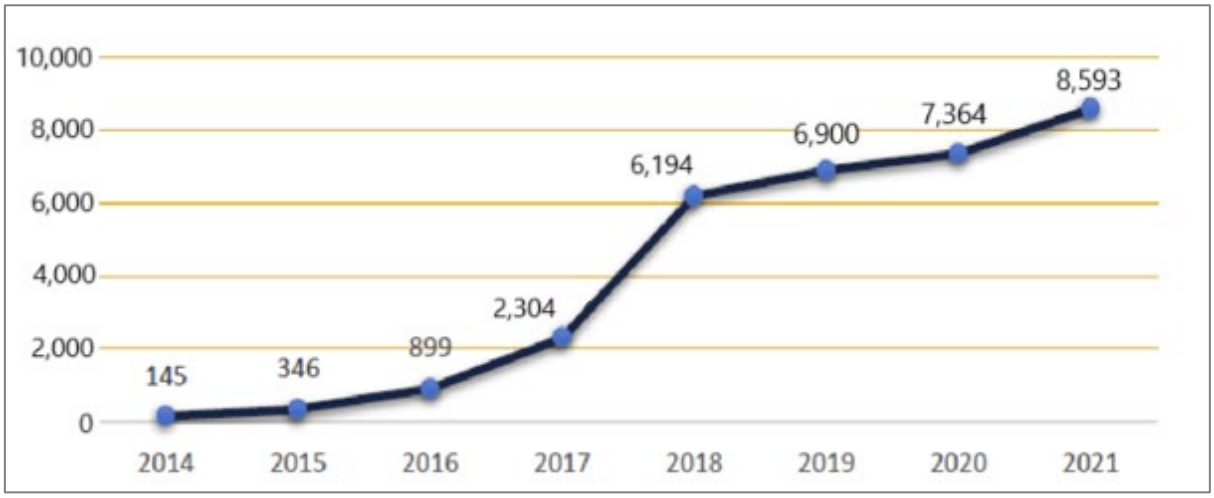


Source: *Philippine Daily Inquirer* (2025).

Several other reports have indicated an expansion of the used car market in the Philippines. One estimated a compound annual growth rate (CAGR) of 7.40% for 2024–2029.[4] Another estimated the increase by volume at a CAGR of 6.9% and by value at a CAGR of 8.9% for 2020–2025 (Ken Research, 2022).

Regarding EV, their registration in the Philippines is not significant but is increasing rapidly; 8,593 EV were registered in 2021 (Figure 2.18).

Figure 2.18. Electric Vehicle Registrations in the Philippines, 2014–2022



EV = electric vehicle.
Source: Department of Energy (2023).

[4] Mordor Intelligence, 'Philippines Used Car Market Size and Share Analysis – Growth Trends and Forecasts (2025–2030)', https://www.mordorintelligence.com/industry-reports/philippines-used-car-market/market-size

While 7,503 sedan-type EV are registered, this figure represents only 0.6% of total sedan-type vehicles registered in 2023 (Table 2.11).

Table 2.11. Registered Motor Vehicles in the Philippines, 2023

Type	No. of ICE Vehicle Registrations	No. of EV Registrations
Cars	1,221,074	7,503
SUV/UV	3,168,602	254
Motorcycles	8,070,821	834
Buses	25,986	
Trucks/trailers	536,000	2

EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, SUV = sports utility vehicle, UV = utility vehicle.
Source: Department of Energy (2023).

EV sales data for the Philippines differ according to source. Table 2.12 shows EV sales data from MarkLines, which shows the number of EV sales as quite small.

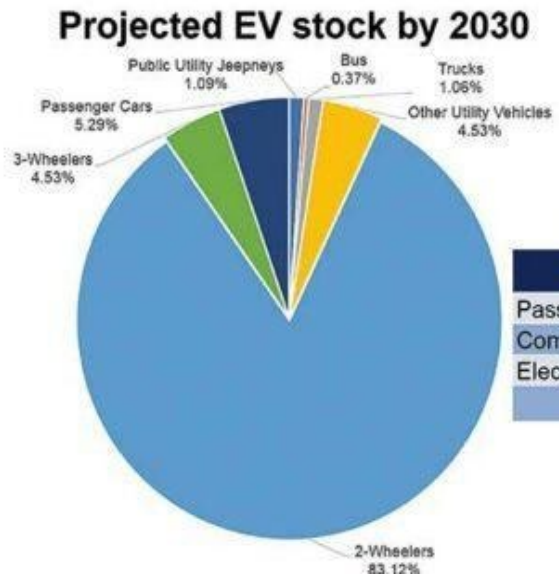
Table 2.12. Electric Vehicle Sales in the Philippines, 2018–2023

Type	2018	2019	2020	2021	2022	2023
BEV	0	1	0	16	2	109
PHEV	3	0	0	0	0	0
HEV	107	0	0	0	0	0
HEV/BEV/PHEV*	0	19	21	14	0	0
Total	**110**	**20**	**21**	**30**	**2**	**109**

*Each manufacturer uses different categories for statistics. Hyundai Motor Group used the category 'HEV/BEV/PHEV' in 2019, 2020, and 2021.
Source: MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search, [accessed 11 March 2025].

The Electric Vehicle Association of the Philippines's 2023 information shows more EV sold (Figure 2.19). There is a possibility that Table 2.12 shows only new EV while Figure 2.19 includes second-hand or used cars.

Figure 2.19. 1st Quarter 2023 and Projection of Electric Vehicle Sales, Philippines



Electric Vehicle Sales 1st Quarter 2023

Category	January	February	March	Total
Passenger Vehicles	7,291	7,008	9,649	23,948
Commercial Vehicles	21,756	23,137	25,907	70,800
Electric Vehicles	452	760	1,324	2,536
Total	**29,449**	**30,905**	**36,880**	**97,284**

Source: Macapagal (2023).

According to the *EV and HEV Comprehensive Road Map* of the Department of Trade and Industry and the Electric Vehicle Association of the Philippines, the industry is targeting increasing the share of EV and HEV in the total vehicle population to 21% by 2030, specifically focussing on public transport (Figure 2.19). By 2040, the industry targets raising the share to 50% EV of total vehicles in the country (Cahiles-Magkilat, 2020).

Regarding ELV, there are no official statistics in the Philippines. One study found that an estimated 80,000 ELV were generated in 2015, and 140,000 will be generated by 2025 (Mitsubishi UFJ Research and Consulting, 2018). Before becoming ELV, post-consumer vehicles are transacted as second-hand cars, which are traded on online selling platforms like Carousell, Facebook Marketplace, Lazada, and Shopee.

ELV in the Philippines are called 'junk cars' and are collected by junkshops. Junkshops also collect car batteries. An inventory of junkshops and recycling facilities was developed by the Environmental Management Bureau (EMB) of the Department of Environment and Natural Resources (DENR), finding about 1,850 junkshops (EMB, 2023). About 1,000 of them are in the National Capital Region, but only some indicated that they deal with vehicle scrap parts (Table 2.13).

Table 2.13. Selected Junkshops Dealing with End-of-life Vehicle Scrap in the Philippines

Region	Location	Junkshops in the Region	Materials Bought
National Capital Region	Many junkshops likely buying ELV scrap, particularly in Manila, Quezon City, and Valenzuela		
4B	Palawan, Pulot Center, Sofronio Española	Manny Junkshop	Metals and tires
6	*Barangays* Iloilo, Oton, Pakiad	1 Local Junkshop	All types of recyclables, including residuals with potential for recycling
	Barangays Capiz, Dao, Nasunogan		
7	Minglanilla, Tungkil	Isiang Triple J Junkshop Inc.	Metals, aluminium, plastics, copper, carton, batteries
8	Motiong, Poblacion 1, Samar	RAF Junkshop	Recyclables and e-waste (i.e. industrial and vehicle batteries)
	Barangays Canlapwas, Pagsanghan, Samar	Emily Store Junkshop	
11	AVD, *Barangays* Libertad, South Cotabato, Surallah	Dedase Junkshop	Solid iron, plastic, bottles, GI sheets, tin, bronze, aluminum, brass, copper, alloy, batteries, paper, carton
	Claudio St., Barangays Libertad, South Cotabato, Surallah,	RL Junkshop	
	Purok Santa Ana, Zone 2-A, Barangays Libertad, South Cotabato, Surallah,	Sheryl Junkshop	
13	Purok 3, *Barangays* Cabugo, Claver, Surigao del Sur	E.T.S. Junkshop	Metals, vehicle parts, plastic bottles, tires, textiles, alloys, copper, container vans, machines, glass bottles, tin cans
	Purok 4, *Barangays* Claver, Ladgaron, Surigao del Sur	JKK Junkshop	Metals, plastic, vehicle parts, copper, alloy, brass, stainless steel, lightbulbs
	Purok 7, *Barangays* Claver, Ladgaron, Surigao del Sur	Catherine Junkshop	

Region	Location	Junkshops in the Region	Materials Bought
	Purok Mapuslanon, *Barangays* Gigaquit, San Isidro, Surigao del Sur	Renz Junkshop	Metal, motor vehicle parts
	Purok Kogtong, Barangays Gigaquit, Poblacion, Surigao del Sur	De Jesus Junkshop	Metals, motor vehicle parts, stainless steel, alloy, copper, plastic bottles, tin cans, glass bottles

Source: EMB (2023).

Junkshop workers dismantle ELV manually and remove usable parts, which are then sold to car parts shops. Retrieved metals are also sold to metal factories. Other waste, such as wire harnesses, plastics, and rubber, are recycled (Figure 2.20).

Figure 2.20. Dismantling of Junk Cars, Philippines

Source: S.G.P., https://www.sgpjunkshop.com/about-us

A field survey in the Philippines was conducted in December 2024. In *Barangay* Tatalon in Quezon City,[5] the *barangay* captain mentioned that vehicle-dismantling activities are often conducted in the evening on the road, in front of the stores, blocking traffic.

[5] *Barangay* is the smallest unit of local government in the Philippines, under the jurisdiction of a city or municipality.

When vehicles are brought to the dismantling sites earlier in the day, documents presented by the ELV seller must be verified. The most important document is the OR/CR, which is the official receipt of registration and the certificate of registration issued by the Land Transportation Office to vehicle owners. When ownership of a vehicle changes, the OR/CR must be re-issued to the new owner; dismantlers are supposed to receive the validated OR/CR. If the OR/CR is not presented, dismantling is not allowed, since this likely means that the vehicle was stolen.[6]

The study team also conducted an interview with the *barangay* secretary in *Barangay* Capalangan, Apalit, Pampanga. He mentioned that dismantlers there accept cars from insurance companies. When a car accident occurs, an insurance company usually provides its client with an alternative car and disposes of the damaged car. If 70% of the body is damaged, the car must be disposed of. This damaged car is to put to auction; owners of parts shops can acquire the car. If the car can be repaired, it can be resold.

An advanced recycling facility, En Tsumugi, was introduced to the Philippines in 2024. The study team conducted interviews with Tsuruoka in August 2024 and January 2025, and En Tsumugi in December 2024. En Tsumugi was created based on Tsuruoka's technology. Tsuruoka is an ELV dismantler and recycler, located in Japan's Tochigi Prefecture. According to information provided by Tsuruoka, its capacity for dismantling ELV is 1,000 units per month, and its capacity for shredding dismantled cars is 4,000 units per month. In recent years, the number of cars dismantled by Tsuruoka was about 600 units per month, while shredded cars totalled 2,500 units per month, making it one of the largest dismantlers in Japan.

In Japan, the number of dismantled used cars in fiscal year 2022 totalled 2,835,568, and there were 4,273 licensed dismantlers, of which 3,251 were operational. This means Tsuruoka's processing volume is about seven times the average. Tsuruoka's business model, known as 'Recyint' – which combines the words 'recycle' and 'integrate' – is to take raw materials to final recycled products.

Introduction of Tsuruoka's technology in En Tsumugi was done through a Japan International Cooperation Agency (JICA) programme to support overseas expansion of small and medium-sized enterprises (SMEs). To reduce sole dependence on China, Tsuruoka joined the JICA programme in search of other overseas suppliers of car scrap, according to an interview conducted in January 2025. It had been purchasing recycled metal only from China to produce various construction machines in Japan.

Mitsui & Co. and Tsuruoka have now shifted from technical support to investment in En Tsumugi. En Tsumugi is the first factory that complies with Toyota recycling standards in the Philippines, while Viet Nam and India have recently opened similar factories. Currently, En Tsumugi is in the process of registration for its environmental permits as an ELV dismantler in the Philippines, including its environmental compliance certificate and registration as a hazardous waste treatment, storage, and disposal facility in consultation with DENR. The details of En Tsumugi are in Box 2.2.

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[6] Note that most illegal dismantling is done in the evening, as no police resources are devoted to stolen vehicles. Quezon City also has limited availability of space to hide stolen cars; they are thus dismantled immediately for parts.

Box 2.2. Profile of En Tsumugi, Philippines

En Tsumugi's factory comprises 36,000 square metres, with 30 people involved in its dismantling operations and 3–4 people working on housekeeping issues.

If it accepts 90 cars, the business is profitable. Its maximum capacity is 50–60 cars at a time, while its storage area can contain 400–500 cars.

En Tsumugi complies with hazardous waste regulations but is struggling as they change yearly. The composition of waste in end-of-life vehicles (ELV) is also changing. Old cars have few electronic devices, but new cars have many.

En Tsumugi is collecting marketing data for ELV, including repair shops and other options. If a database for ELV and used parts can be standardised in ASEAN, it can be monetised. Regulation of international trade of ELV and used parts is also an issue (e.g. En Tsumugi cannot bring ELV in from the Lao People's Democratic Republic).

In January 2025, En Tsumugi began the dismantling of 259 used taxis under a contract with a taxi company in Davao City. The taxi company is replacing internal combustion engine taxis with electric taxis.

A well-known area for second-hand automobile parts is the town of Apalit, Pampanga, located north of Manila. Car part shops include AGL Original Surplus Auto Parts, Apalit Surplus Auto Parts, Auto Parts Capalangan Apalit Pampanga, Capalangan Apalit Original Surplus Car Parts, Totong Ko Autoparts, and Triple R Autoparts. Other areas for second-hand auto parts are along C3 Road, Rizal Avenue (Recto), Abad Santos Avenue in Manila, Mindanao Avenue in Quezon City, and Banaue Street in Quezon City. Similarly, second-hand parts for motorcycles are also traded.

In the field survey of *Barangay* Capalangan in Apalit, the *barangay* secretariat explained that approximately 80 used car parts shops are registered with business permits. In addition, shops without permits exist. An automobile parts association was established in *Barangay* Capalangan and surrounding *barangays.* In some *barangays,* dismantlers have been investigated by police, with suspicion that they committed crimes, such as dismantling stolen cars or reassembling stolen parts to produce a car that no longer resembles the stolen car. To prevent such criminal activities, dismantlers founded the association. The trade of used car parts is usually conducted amongst members of the association.

In Apalit, parts in shops are taken from the cars from insurance companies or purchased from other junk shops. Each shop is specialised in one part of a car. The study team visited three shops; Shop A has dashboards, Shop B has headlights, and Shop C has suspension and springs. The owner of Shop A had experience working as a car repairer in Saudi Arabia. Now he repairs damaged dashboards and sells them. Shop B sorts various kinds of headlights according to brand and shape; it also cleans damaged lights, replaces damaged headlight parts, and sells them. It stocks spare parts of headlights for repair. Shop C sorts various springs and suspensions for repair (Figure 2.21).

Figure 2.21. Car Parts Shops, Apalit, Pampanga, Philippines

Source: Authors.

Importers of used car parts also exist. The study team visited a company in *Barangay* Tatalon, Quezon City that specialises in selling used engines imported from Japan for use in repairing Japanese cars. Engines were imported twice per month before the pandemic; now, the cargo comes in only three times a year. After unloading, half of the engines are sold within 2 weeks, while others are used for parts. The shop also has a stock of undercarriage parts. When a client brings a non-Japanese brand car in, the shop can purchase the necessary parts from other shops. When engines are not sold or used for repair, they are sold to a junk shop that sells them as scrap or are purchased by other shops.

In the field survey, the *barangay* secretary of *Barangay* Capalangan stated any unusable vehicle part is supposed to be sold to junkshops. Plastic bumpers and other plastic parts should be shredded and passed to junkshops, which bring them to dumps. Metal parts that remain unsold should also be disposed of, but these can also be sold as scrap. According to the World Bank, the Philippines is one of the biggest exporters of waste, scrap, tinned iron, and steel to China (World Bank, 2023).

Barangays are obliged to collect waste according to Republic Act No. 9003. One of the *barangay*'s roles is to transport waste, including plastics, to designated collection stations or material recovery facilities. The municipality or city to which the *barangay* belongs must establish waste disposal plans, including for hazardous waste from automotive parts dismantling. The *barangay* secretary of *Barangay* Capalangan mentioned that no waste plan for the next year has been detailed. Thus, unsellable auto parts and spare parts (e.g. fender guards) have been thrown into creeks surrounding the *barangay,* which are tributaries to the Pampanga River.

In the case of the second-hand parts importer in Quezon City, waste oil is collected and sold to a designated partner, who sells it to junkshops. One drum (around 200 litres) can be sold for PHP1,000. In a week, up to six drums can be collected.

The Philippines has ratified the Paris Agreement; thus, the proper disposal of CFC and HFC gases is key. There have been previous collection programmes in the past for such gases, and some are stored at a centralised facility in Rizal Province managed by DENR. However, no destruction facility exists for these collected substances. One company, Delsa, which imports and wholesales refrigerants and handles air-conditioning construction in the Philippines, has been certified by EMB as a CFC and HFC recovery company. However, it has a shortage of cylinders for storing these gases and is unable to destroy them. Thus, they remain on Delsa's premises. Marubeni is planning to construct a demonstration plant under a Joint Crediting Mechanism (JCM) project from the Ministry

of the Environment, Japan.

2.2.4 Singapore

The number of newly registered vehicles in Singapore showed an overall increasing trend before the pandemic. After the pandemic, the number did recover to the pre-pandemic level but showed a downward trend (Table 2.14).

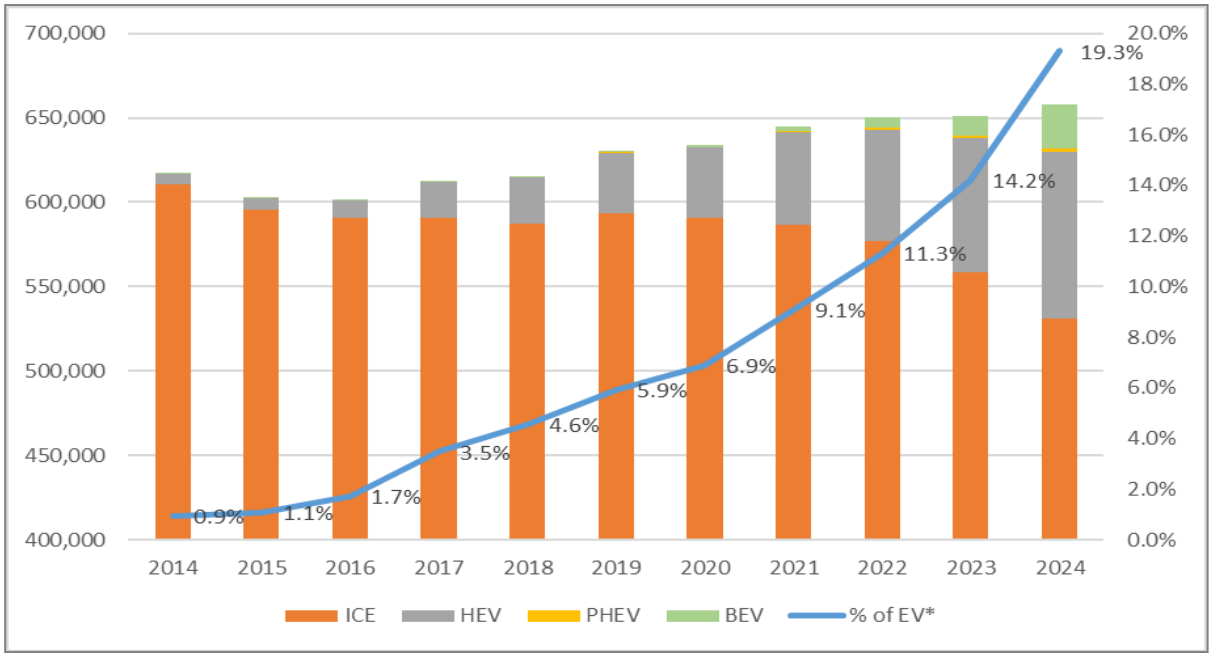
Table 2.14. Vehicles Newly Registered in Singapore

Year	Total	Category A	Category B	Category C Goods Vehicles and Buses		Category D Motorcycles	Taxis	Vehicles Exempted from the VQS
					ETS			
2013	45,761	9,191	12,817	5,665	491	11,650	3,490	2,457
2014	55,588	12,326	16,289	6,298	5,671	8,145	4,192	2,667
2015	86,068	30,972	26,480	5,573	9,106	7,459	4,060	2,418
2016	118,791	49,300	38,002	4,786	12,179	8,336	3,794	2,394
2017	125,788	46,076	45,699	12,055	7,706	9,640	2,770	1,842
2018	107,296	39,877	40,216	6,539	5,824	12,053	1,344	1,443
2019	109,785	36,187	36,031	7,897	5,568	19,356	3,549	1,197
2020	66,967	18,528	25,779	6,101	3,336	10,544	1,349	1,330
2021	70,381	19,357	25,879	4,851	6,091	11,428	1,188	1,587
2022	54,566	13,811	16,661	2,101	7,477	12,016	506	1,994
2023	50,881	14,911	14,814	2,026	4,133	12,211	968	1,818

ETS = Early Turnover Scheme, VQS = Vehicle Quota Scheme.
Source: LTA, 'Statistics about Motor Vehicles', https://www.lta.gov.sg/content/ltagov/en/who_we_are/statistics_and_publications/statistics.html [accessed 10 February 2025].

Although the number of BEV in Singapore has been increasing sharply in recent years, the total number of BEV in the country is still small compared to the total vehicle population. However, the number of EV and HEV has already reached over 15% of the total vehicle population and is growing steadily (Figure 2.22).

Figure 2.22. Cars by Type of Engine in Singapore



BEV = battery electric vehicle, EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid vehicle.
Note: 'EV' includes BEV, HEV, and PHEV.
Source: LTA, 'Statistics about Motor Vehicles', https://www.lta.gov.sg/content/ltagov/en/who_we_are/statistics_and_publications/statistics.html [accessed 10 February 2025].

Singapore aims to reduce emissions from land transport in support of its net-zero emissions goal. Under the *Singapore Green Plan 2030*, all new car registrations will have to be cleaner-energy models from 2030, which includes BEV, HEV, and FCEV, and will also stop allowing new diesel car registrations from 2025. It is also planned that 100% of vehicles will be running by cleaner energy in 2040.

There is no specific statistical data for the generation of ELV in Singapore, but these can be gleaned from the number of vehicles deregistered every year. Failure to dispose of deregistered vehicles leads to a fine or imprisonment; therefore, people scrap them at a Land Transport Authority (LTA)-appointed scrapyard or export or store them in export-processing zones. The number of deregistered vehicles was 27,169 from January to June 2024, while the number of newly registered vehicles was 29,306.[7]

[7] LTA, 'Statistics about Motor Vehicles', https://www.lta.gov.sg/content/ltagov/en/who_we_are/statistics_and_publications/statistics.html [accessed 10 February 2025]

Table 2.15. Number of Vehicles Deregistered in Singapore, 2013–2023

Year	Total	Category A	Category B	Category C Goods Vehicles and Buses	Category D Motorcycles	Taxis	Vehicles Exempted from the VQS
2013	41,501	9,329	8,944	7,107	10,630	4,005	1,486
2014	57,721	18,562	14,811	11,868	8,052	3,151	1,277
2015	100,859	44,450	27,302	14,974	8,583	4,537	1,013
2016	119,607	53,191	35,126	16,687	9,165	4,519	919
2017	120,376	45,621	35,167	20,685	10,786	7,164	953
2018	112,132	43,719	33,142	13,817	16,515	3,903	1,036
2019	93,690	29,778	27,783	13,841	15,933	5,588	767
2020	66,078	20,494	20,353	10,051	10,153	4,213	814
2021	55,616	16,994	17,122	8,240	10,615	1,979	666
2022	47,575	13,471	11,467	9,043	11,145	1,309	1,140
2023	49,895	16,914	12,175	7,116	11,174	1,432	1,084

VQS = Vehicle Quota Scheme.
Source: LTA, 'Statistics about Motor Vehicles', https://www.lta.gov.sg/content/ltagov/en/who_we_are/statistics_and_publications/statistics.html [accessed 10 February 2025].

With stringent policies such as the certificate of entitlement (COE) system and high vehicle ownership costs, steady generation of ELV is foreseen based on the normal length of registration of 10 years in Singapore.

The collection of ELV in Singapore is managed through a network of authorised scrapyards and recycling facilities (Table 2.16). The government mandates that vehicles due for deregistration must be sent to authorised scrapyards for proper disposal and recycling. These facilities are equipped to handle the various stages of ELV processing, from the initial collection to the dismantling of parts and recycling of materials. Vehicle owners are required to surrender their vehicles to these facilities, where the vehicles are inspected, and the valuable components are salvaged before the remaining parts are processed for recycling.[8]

[8] LTA, 'Deregister a Vehicle', OneMotoring, https://onemotoring.lta.gov.sg/content/onemotoring/home/selling-deregistering/deregister-a-vehicle.html

Table 2.16. LTA-appointed Scrapyards in Singapore

Company	Address	Contact Details	Operating Hours
Esun International Pte Ltd	17 Tractor Road Singapore 627975	Tel: 6866 0220 Email: sales@esun.com.sg Website: www.esun.com.sg	Monday to Friday: 8.30 am - 6.00 pm Saturdays: 8.30 am - 12.00 pm (Closed on Public Holidays)
Hup Lee Leong Hardware Pte Ltd	26 Sungei Kadut St 3 Singapore 729153	Tel: 6363 5055 Email: vehicle@hll.com.sg Website: www.hll.com.sg	Monday to Friday: 8.30 am - 5.30 pm Saturdays: 8.30 am - 4.30 pm (Closed on Public Holidays)
Kheng Keng Auto Pte Ltd	56 Pandan Road Singapore 609293	Tel: 6844 3333 Email: yihui@khengkeng.com Website: www.khengkeng.com	Monday to Friday: 8.30 am - 5.30 pm Saturdays: 8.30 am - 5.00 pm (Closed on Public Holidays)
Kiat Lee Machinery Pte Ltd	213 Kranji Road Singapore 739485	Tel: 6368 8832 Email: sales@kiatleegroup.com Website: www.kiatleegroup.com	Monday to Friday: 9.00 am - 5.30 pm Saturdays: 9.00 am - 3.00 pm (Closed on Public Holidays)

LTA = Land Transport Authority.
Source: LTA, 'Deregister a Vehicle', OneMotoring, https://onemotoring.lta.gov.sg/content/onemotoring/home/selling-deregistering/deregister-a-vehicle.html

Singapore has developed a robust recycling infrastructure, supported by both governmental regulations and private sector investments, to ensure that the ELV recycling process is efficient and environmentally friendly (Dorian, 2023). The typical process of ELV recycling is as follows.

Depollution process. The first step involves the safe removal of hazardous materials from ELV. This includes the extraction of fluids such as oil, coolant, brake fluid, and other substances that could pose environmental risks. Batteries, air-conditioning units, and other components containing harmful chemicals are carefully removed and processed separately to ensure that they do not contaminate the recycling process.

Dismantling. Once the ELV are depolluted, the next stage is dismantling. This involves removing reusable parts that can be resold or refurbished. Components such as engines, transmissions, doors, and electronic parts are extracted. The dismantling process is crucial for recovering parts that have a second life, either as spare parts for other vehicles or as materials for other industrial uses.

Shredding and material recovery. After dismantling, the remaining vehicle body is sent to a shredding facility. Here, the vehicle is shredded into small pieces, and the materials are sorted using various techniques, including magnetic separation for metals. The primary materials recovered are ferrous metals (e.g. steel) and non-ferrous metals (e.g. aluminium). These materials are then recycled and reintroduced into the manufacturing process, reducing the need for raw materials extraction.

Plastic and non-metallic material recycling. Plastics and other non-metallic materials are separated during the shredding process. These materials are further processed to remove contaminants and can be recycled into new products. Innovations in recycling technology have enabled better recovery and reuse of these materials, contributing to a circular economy.

Energy recovery from residues. Materials that cannot be economically recycled are often sent to waste-to-energy facilities. In these plants, the residual waste is incinerated to generate electricity, reducing the volume of waste that ends up in landfills. This process helps manage waste sustainably by converting it into a useful form of energy, aligning with Singapore's environmental goals.

Since all scrapyards must be authorised in Singapore, Singapore's regulatory framework ensures that the entire recycling process complies with stringent environmental standards. This includes regular inspections and audits of recycling facilities to ensure adherence to best practices. Policies and regulations are continually updated to incorporate new technologies and methods that enhance the efficiency and effectiveness of ELV recycling.

As for the e-waste in ELV, Singapore introduced an extended producer responsibility (EPR) scheme in 2021, which requires electronic goods producers and retailers to recycle their products when they are disposed of. According to the statistical data on the recycling rate of e-waste from the National Environment Agency (NEA), about 10,000 tonnes of e-waste were recycled from 2021 to 2023; however, this is a fraction of the estimated 60,000 tonnes of e-waste that Singapore produces each year. It was also reported that EV batteries account for just 1% of e-waste recycled under the EPR scheme.

About 130 tonnes of EV batteries have been received by recyclers. After being discharged (i.e. drained completely of stored energy), a battery is dismantled. This is usually automated because of safety, as each battery weighs several hundred kilograms. Dismantled battery cells are then shredded. The shredded material is separated mechanically – using air, magnets, or sieves – into four main groups: paper/plastic, ferrous metals, non-ferrous metals, and black mass (i.e. the remainder of which cannot be mechanically separated). Black mass is sent for chemical separation, resulting in end-products such as graphite, cobalt hydroxide, and lithium carbonate. Recycled materials are refined further before they can be used to make new batteries. According to SK Tes (a battery-recycling company) Chief Strategy Officer John Oh, the mining of recycled materials emits up to 30 times less carbon dioxide than conventional mining. With the increasing number of EV in Singapore, many battery-recycling companies and plants have been established in recent years (Tan, 2024).

The final stage in the ELV recycling process is the disposal of residue, which includes materials that cannot be recycled economically or safely. This includes certain plastics, rubber, and other composite materials. In Singapore, the disposal of residue is managed through environmentally sound methods.

Landfills were the primary means of disposal in the 1960s and 1970s, but landfilling has been minimised, with a focus on reducing waste through advanced recycling techniques and energy recovery processes. The country's land scarcity led NEA to start using a waste-to-energy incineration plant in Ulu Pandan for some of Singapore's trash beginning in 1979. Today, residual waste is often sent to such plants, where it is incinerated to generate electricity, thus minimising the environmental impact and contributing to the country's energy needs.

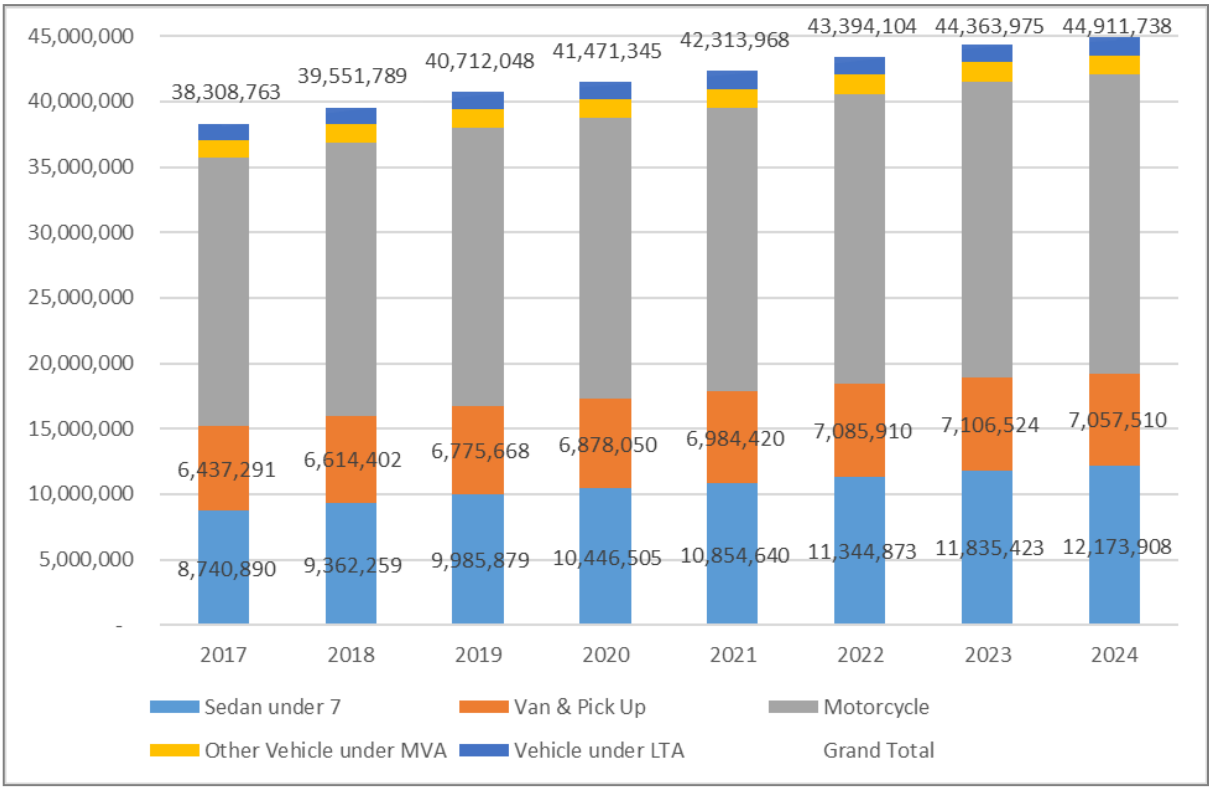
Singapore disposes of much of its waste through waste-to-energy initiatives. Of the 7.23 million tonnes of solid waste generated in 2019, more than 40% was incinerated (Trang, 2021). In 2016, NEA operated four waste-to-energy plants: Keppel Seghers, Senoko, Tuas, and Tuas South, with the Ulu Pandan plant closing in 2009.

Incineration reduces the volume of the waste to just 10% of its former volume (Min and Co, 2021). Some recycling also occurs in this process, as heat from incineration is utilised for generating electricity, and recovered ferrous metal goes to recycling mills. Ash from waste incineration is sent to the Tuas Marine Transfer Station where it is unloaded onto barges before being transported via sea to the final stop, Semakau. Semakau Landfill, which is located 8 kilometres from the south of Singapore, is a 350-hectare swathe of sea space enclosed by a sand bund with a 7-kilometre perimeter. It is Singapore's only landfill, and its capacity is meant to be sufficient for all the ash and non-incinerable waste generated in Singapore from 1999, when the landfill first opened, until at least 2035 (Thean, 2016).

2.2.4. Thailand

According to the Department of Land Transport (DLT), the total number of registered vehicles in Thailand as of July 2024 was around 43 million, while the number of sedans and pick-up trucks was around 19 million. The number of vehicles registered increased from 2017 to 2024 (Figure 2.23).

Figure 2.23. Number of Vehicles Registered in Thailand, 2017–2024

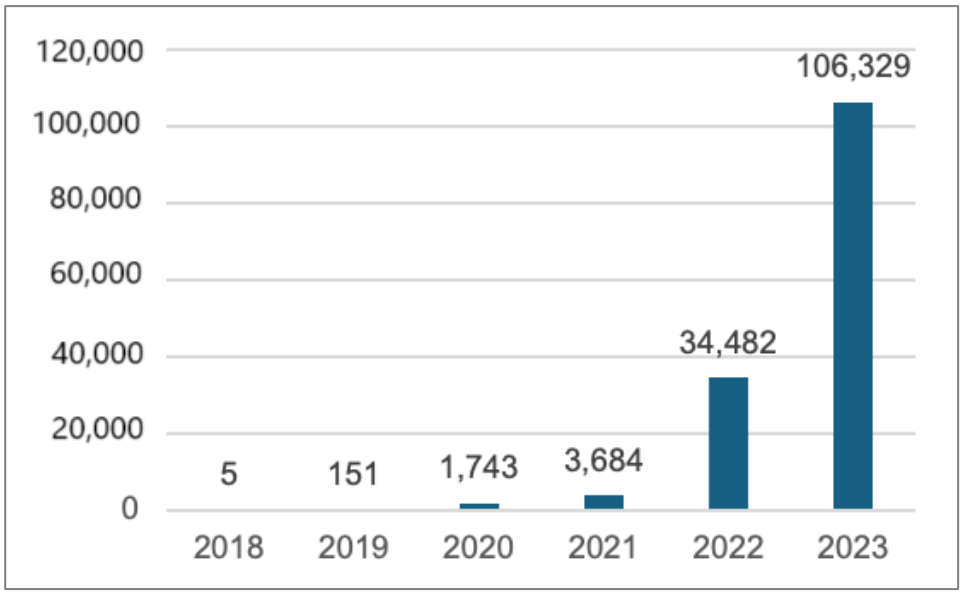


Source: Transport Statistics Group, Planning Division, Department of Land Transport, https://web.dlt.go.th/statistics/ [accessed 10 February 2025].

Meanwhile, according to statistical data from DLT, the number of old vehicles is rising, while the number of new cars is steady. This indicates that drivers continue to use old cars.

The sales of EV in Thailand have increased sharply over the past several years (Figure 24). EV registration is increasing rapidly; due to governmental support and comparatively lower purchasing and running costs, EV are popular, especially in Bangkok. The government has committed to propelling Thailand into a prominent regional hub for EV manufacturing, aligning closely with the 30@30 Policy, which aims to produce zero-emissions vehicles that account for at least 30% of overall motor vehicle production in Thailand by 2030. The government defines zero-emissions vehicles as BEV and FCEV (Office of the National Economic and Social Development Council, 2023). This target equates to manufacturing around 725,000 zero-emissions vehicles (including passenger cars and pick-up trucks) and 675,000 zero-emissions motorcycles (Thailand Board of Investment, 2023a).

Figure 2.24. Number of Electrical Vehicles Registered in Thailand, 2018–2023



Source: MarkLines, 'Search by Model/EV/etc.', https://www.marklines.com/ja/vehicle_sales/search, [accessed 11 March 2025].

In November 2023, the National Electric Vehicle Policy Board granted approval for the second phase of the EV Package for 2024–2027 (Thailand Board of Investment, 2023a). The purposes are to support the ongoing expansion of the EV industry and to encourage investment opportunities in EV manufacturing in Thailand. As part of the package, the government will provide subsidies for the purchase of electric cars, pick-up trucks, and motorcycles based on vehicle type and battery capacity. In addition, for electric passenger cars below a certain price, further reduction on excise tax and import duties will be applied. For electric trucks and buses – and even battery-cell manufacturers – governmental policies will support tax incentives or cash grants. The EV Package also promotes sustainable development within Thailand's automotive manufacturing sector to further solidify Thailand's position as a leader within ASEAN and globally.

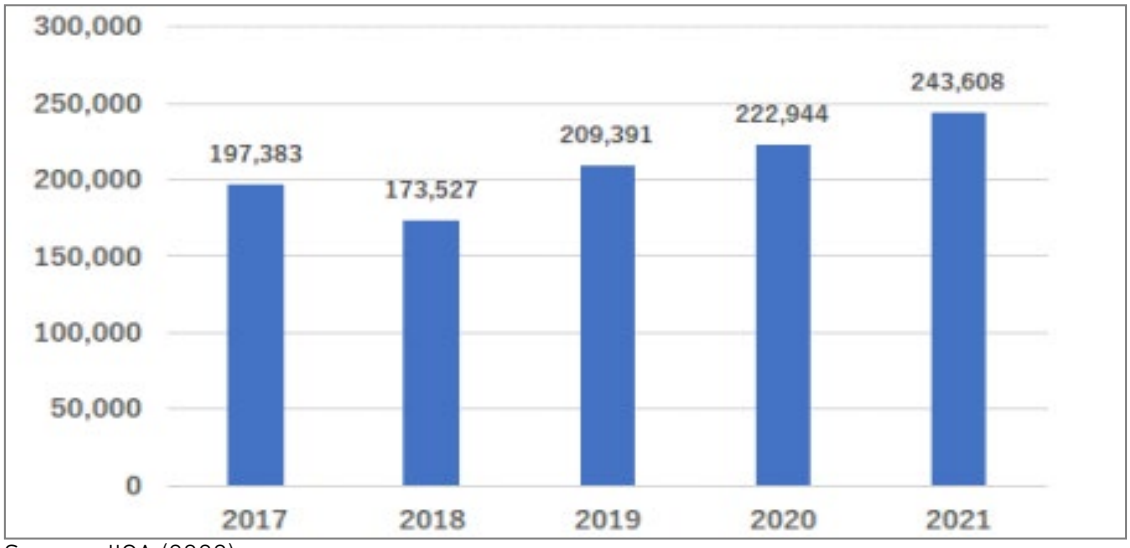
In Thailand, drivers continue to use cars as long as possible, but old cars cause air pollution and safety problems. According to the field study, when used cars become older, drivers generally resell the cars to rural areas or to neighbouring countries.

There are no statistics related to the number of ELV in Thailand because DLT does not enforce the requirement for vehicle owners to deregister. Instead, after 3 years of failing to renew road taxes, DLT automatically erases those vehicles from the registration system. However, Figure 2.25 shows the results of an estimation based on data from a 2020 survey (JICA, 2023).

The estimation was calculated as:

Generation of ELV = Number of vehicles owned at the end of the previous fiscal year + number of newly registered vehicles at the end of the current fiscal year – number of vehicles owned at the end of the current fiscal year.

Figure 2.25. Expected Number of End-of-life Vehicles in Thailand, 2017–2021



Source: JICA (2023).

Records from DLT indicate that the average number of privately owned cars reported as not in use or having their registrations cancelled is 19,000 per year. Furthermore, there are vehicles with suspended registrations due to unpaid taxes over 3 consecutive years, accumulating to a total of 1.89 million vehicles from 2004 to 31 March 2018. Both types of vehicles have been removed from the registration system, and it can be assumed that such cars have already reached the end of their lives. According to the law, these cars cannot be legally operated (Section 6 of the Vehicle Act, B.E. 2522).

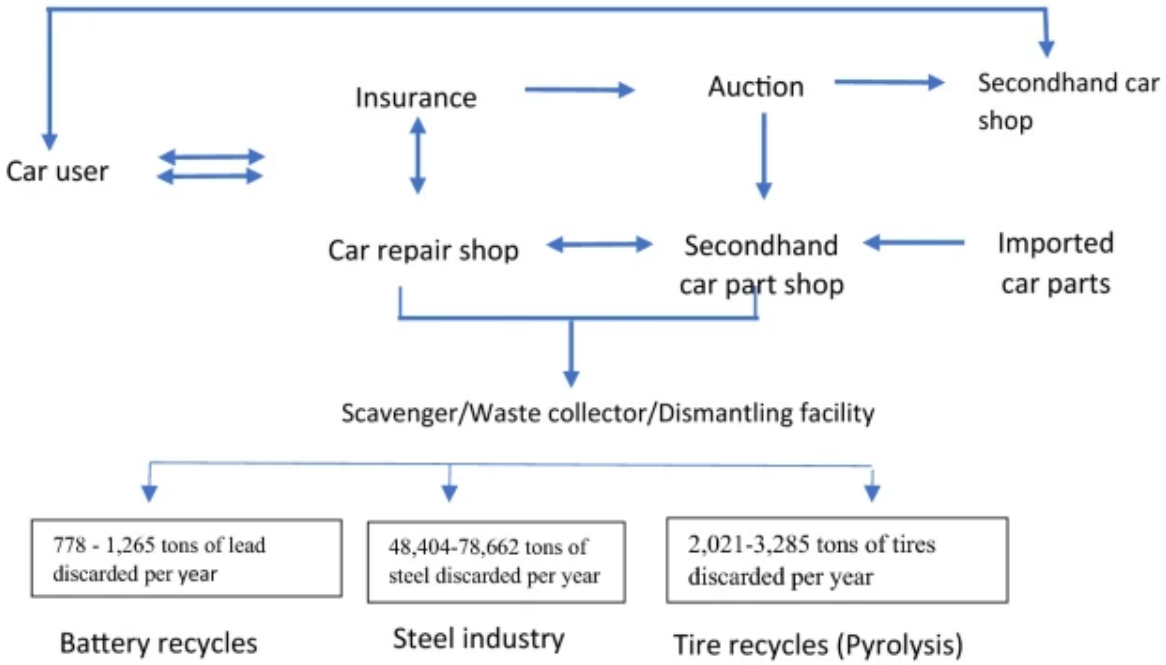
The Ministry of Industry estimated that in the next 20 years, there will be an additional 16 million cars older than 20 years. Amongst this number, 200,000–300,000 ELV will be generated annually. [9] However, due to the absence of regulations governing the procedures for vehicle owners to follow when their cars are no longer in use – and the lack of a vehicle tracking and data collection system for unused vehicles – it is not possible to ascertain how these vehicles have been managed. Some vehicles may have been re-registered in accordance with the law, while others may have been unlawfully used or dismantled as ELV with their components separated and/or destroyed.

The collection of ELV is one of the weakest links in the ELV management chain in Thailand. Several companies can dispose of ELV and recycle their parts while meeting the high standards of developed countries. Yet because collection process in Thailand is still dominated by the informal sector, these companies have difficulty securing ELV to be processed, according to the field study.

Figure 2.26 shows ELV management in Thailand. Vehicle users directly access the network of informal sector players, which includes small scrapyards and individual collectors, as well as dealers in the second-hand vehicle business. These operations often lack proper regulatory oversight, leading to inconsistent practices in ELV handling and documentation.

[9] Enviliance ASIA, Progress of End-of-Life Vehicles (ELVs) Management in Thailand, https://enviliance.com/regions/southeast-asia/th/th-waste/th-elv

Figure 2.26. End-of-Life Vehicle Management in Thailand



Source: Mangmeechai (2022).

During an interview with local recyclers during the field study in Thailand, the study team found that vehicle owners obtain the information of local recyclers from advertisement banners both offline and online, via SMS, or even through friends. Many recyclers also purchase ELV from auctions and governmental entities like the Vehicle Collection Center of Bangkok (Figure 2.27).

Figure 2.27. End-of-life Vehicle and Local Recyclers in Thailand

ELV Collected

Advertisement Banner

Vehicles for Auction

Vehicle Collection Center of Bangkok

ELV = end-of-life vehicle.
Source: Authors.

Without any regulated collection system, many ELV end up in unregulated scrapyards or abandoned in public spaces, leading to environmental pollution and the loss of valuable, recyclable materials. The field study also found that the lack of a centralised system for tracking and collecting ELV makes it difficult to ensure that all ELV are properly managed. As previously noted, many ELV are not formally recorded when they are no longer in use, which results in a lack of accurate data on the number of ELV generated, collected, and processed in the country. This data gap hampers efforts to develop comprehensive policies and strategies for ELV management, leading to potential environmental risks.

During the field study, it was noted that many vehicle owners are hesitant to dispose of their old vehicles and often tend to keep them as secondary or back-up vehicles even when they are no longer suitable for driving. This practice further complicates the collection process, as these vehicles may not be considered for formal disposal until they are completely unusable. People can receive money by selling their old cars to recyclers, at least for the metal scraps. Compared to developed countries, there is still a long-standing tradition in Thailand of recognising cars as valuable assets, which can be a huge barrier to establish a formal collection process for ELV.

Efforts to improve the collection of ELV are ongoing, according to local institutes and stakeholders interviewed during the field study. These include initiatives to incentivise vehicle owners to turn their ELV over to authorised collection centres. The government is

also exploring the possibility of introducing regulations that would require vehicle owners to dispose of their ELV through formal channels. Additionally, partnerships with the private sector are being considered to enhance the infrastructure and logistics for ELV collection.

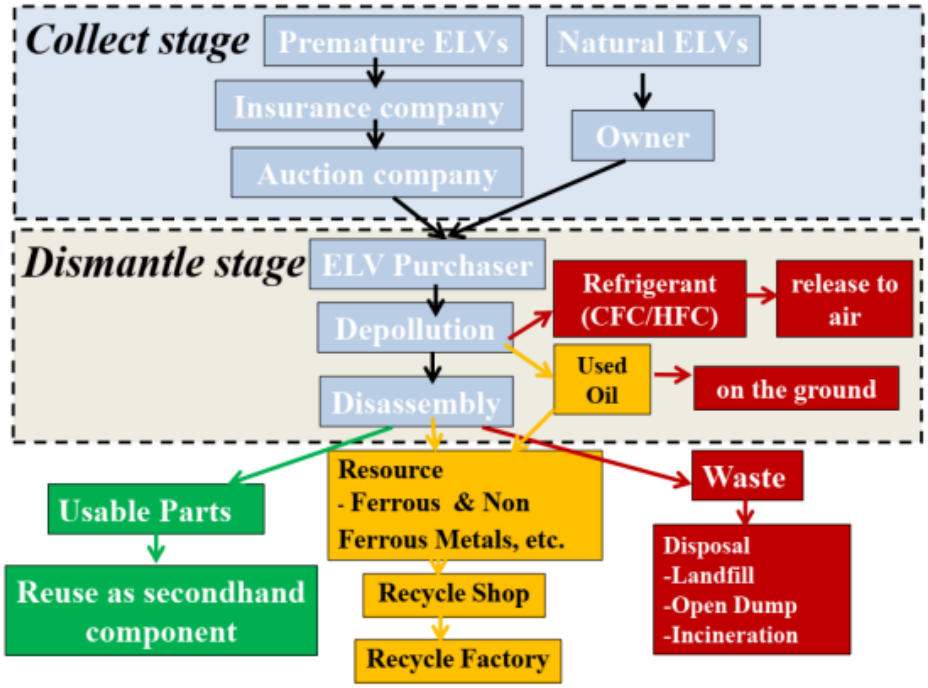
The government has been deliberating on drafting laws that mandate vehicle manufacturers and importers to assume responsibility for the proper disposal of their end-of-life products. If the consideration process succeeds, it will encourage them to incorporate environmentally friendly practices throughout the vehicle life cycle. In addition to legislative actions, the government has proactively collaborated with industry stakeholders to develop initiatives and programmes aimed at promoting responsible ELV management. Partnerships amongst the government, automakers, recycling companies, and other relevant entities have been established to facilitate the creation of more dismantling centres and recycling facilities.[10]

In May 2023, the Director General of the Department of Industrial Works (DIW) and the Director General of the Pollution Control Department co-chaired a meeting to discuss collaborative mechanisms amongst three key agencies – DLT, DIW, and the Pollution Control Department – regarding the management of ELV. Further, during the First National Environmental Committee meeting of 2023, deliberations focussed on measures to address particulate matter pollution during crises as well as on long-term plans for 2023–2026. Strategies were formed that encourage the public to properly dispose of vehicles older than 20 years. Additionally, measures were proposed to limit the number of vehicles and factories as well as to adopt efficient and environmentally friendly vehicle scrappage methods.[11]

Figure 2.28 shows the common flow of ELV being recycled in Thailand.

[10] *Ibid.*
[11] *Ibid.*

Figure 2.28. Flow of End-of-Life Vehicle Recycling in Thailand



ELV = end-of-life vehicle.
Source: Kriengkrai, Honklin, Phamaranon (2019).

In March 2022, there were only two fully integrated automobile dismantling factories currently in operation: Hidaka Yookoo Enterprises in Chachoengsao Province and Wongpanit International in Ayutthaya Province.[12] These factories handle the collection of ELV, their dismantling, and disposal of waste generated that cannot be efficiently utilised. According to an interview with Hidaka Yookoo Enterprises, the company dismantled 6,000 ELV from the 2011 floods in Thailand; specific data on ELV dismantled each year could not be found.

Under the current market mechanism, ELV dismantlers prioritise the recycling and use of reusable parts and highly valuable metal scrap, while other materials – such as plastics with low market value, hazardous waste such as waste oil and waste liquid, waste batteries, and CFC – are not properly collected, treated, nor disposed of.

There are many informal dismantlers in Thailand. According to an interview, there could be 10,000 just around Bangkok. In most cases, used parts recyclers mostly run the dismantling business together and with vehicle dismantlers.

According to an informal dismantler that the study team visited, it usually buys old cars through internet advertisements or on a person-to-person basis. Old cars are dismantled, and it sells usable dismantled parts to end-users or repair shops. Valuable materials, such as metals, plastics, rubber, and glass, are also recovered and sold. Most processes are performed by hand, so the efficiency is limited due to the lack of advanced equipment.

Steel scraps generated in the process of dismantling are sent to or collected by recyclers. Mufflers containing rare metals are also sold to recyclers. Steel scraps are sold to

[12] *Ibid.*

scrap-trading companies in neighbouring areas. Some industrial scrap-trading companies are considering introducing shredders, but the amount of generation is usually not economically sufficient to introduce shredders for ELV.

Waste oil and CFC are usually not recycled nor properly treated; CFC are usually released into the atmosphere, while waste oil is saved to clean recycled parts but is not processed properly afterwards (Figure 2.29).

Figure 2.29. Informal Dismantler Facility in Thailand

Recycled Parts for Sale

Metal Scrap for Sale

Waste Oil Collected in Bottles for Future Use

Batteries for Sale

Forklift Used for Dismantling

Burners Stored in Open Air

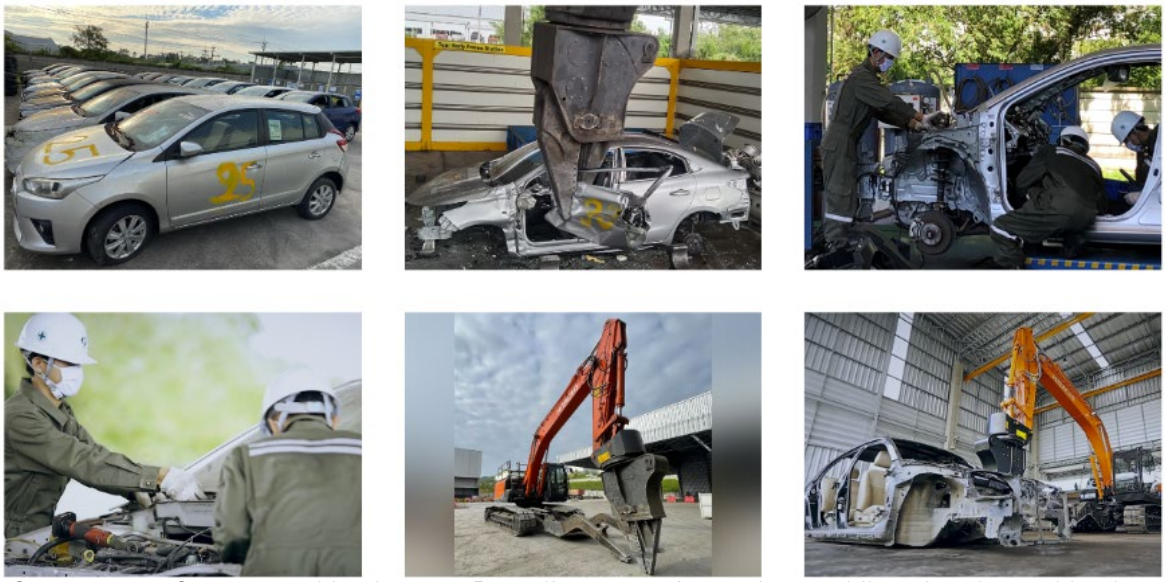
Source: Authors.

Although informal recyclers are supposed to submit necessary registration documents to the local government, inspectors do not usually check unless something is reported. Therefore, informal recyclers are careful not to create noise and odours during the dismantling process, while they care little about other environmental issues including ozone depletion and hazardous waste management.

In 2019, the Ministry of Industry signed a memorandum of understanding for a pilot ELV project in collaboration with the Industrial Estate Authority of Thailand and the New Energy and Industrial Technology Development Organization, a Japanese funding agency. The project aims to establish an efficient and appropriate resource circulation system for ELV in Thailand, focussing on energy conservation and recycling (NEDO, 2019). The goal is to develop a circular economy model in Thailand as well as Asia in the future. As part of this collaboration, a standard working manual for vehicle dismantling [13] and appropriate practices for dismantling ELV have been compiled. These guidelines are expected to provide management strategies and incentives for individuals to properly dispose of their old vehicles, thereby stimulating economic activity by encouraging the purchase of environmentally friendly new vehicles.

The Director-General of DIW has also emphasised the importance of the circular economy in car scrap management by introducing Green Metals as a model factory for proper and environmentally friendly car scrap management, promoting recycling and resource circulation for the industrial sector (Figure 2.30).

Figure 2.30. Processing Procedure of Green Metals (Thailand) Co.



Source: Green Metals, Recycling of Automobile-related Metals, https://www.gmth.co.th/product.php?id=2

[13] In Japan, car dismantlers and shredding companies should develop a standard working manual as well. The Ministry of the Environment issued a guideline to help develop it (Ministry of the Environment 2014). A standard working manual includes how to transport, store, collect waste oil and liquid, manage waste oil separation equipment, dismantle ELV, dispose of residue, and conduct maintenance inspections.

However, according to an interview during the field study, this factory is barely in operation, as vehicle owners still tend to bring ELV to the informal sector. Green Metal is thus facing difficulties in gathering ELV from the market to meet the cost of recycling process. Currently, this factory receives test vehicles from car manufacturers, but the number is limited to around 40 vehicles per month. According to the interview, it is estimated that approximately 1,000 vehicles need to be dismantled per month to cover the operational costs and expenses associated with the proper dismantling process under current circumstances.

The disposal of residue from ELV recycling in Thailand presents another critical environmental challenge (Kojima, 2018). Residue from ELV includes non-recyclable materials and hazardous waste, such as fluids, batteries, and certain plastic components, which require careful management to prevent environmental contamination. However, current disposal practices in Thailand are often inadequate, leading to significant environmental risks.

According to an interview during the field study, there are only a few companies in Thailand that possess the technology to handle the disposal of CFC, liquid waste, and other hazardous materials related to dismantling ELV, and the country does not have a corresponding permitting system in place. Therefore, most are directly released to the environment and cause soil and air pollution.

For the informal sector, the present treatment situation of the waste contained in ELV is summarised in Table 2.17.

Table 2.17. Treatment of Waste Contained in End-of-life Vehicles in Thailand's Informal Sector

Waste Type	Status Quo	Remarks
CFC	Direct emission into atmosphere	Used parts dealers do not have a collection machines.
Airbags	Reuse	Some companies use parts as is or remove parts and reuse them.
ASR	Abandoned or stored on site	Residue after demolition (glass, urethane, rubber, some plastics, tires, etc.)
Waste oil	Usually not recycled; some stored for recycling	In some cases, waste oil is used to clean up other vehicle parts or sold to collectors as valuable material.
Long-life coolant	Usually not recycled	Directly released, but some local companies can recycle
Tires	Recycled or stored on site	Sold as second-hand; sometimes included in ASR
Batteries	Recycled	Available for sale, but some are dumped in rural areas

ASR = automotive shredder residue, CFC = chlorofluorocarbon.
Source: JICA (2023).

These treatments require appropriate handling for the environment. However, in many cases, residue from ELV is disposed of in landfills, which can result in the leaching of hazardous substances into the soil and water. To address these issues, the government is exploring several options, including developing new waste treatment facilities and strengthening regulatory enforcement. Many foreign companies are also contributing to a formal process of treating these kinds of hazardous materials. For example, Bangpoo Environmental Complex and Eastern Seaboard Environmental Complex, which are subsidiaries of Dowa from Japan, are conducting intermediate treatment of industrial waste (i.e. volume reduction by incineration), and their final disposal of industrial waste is carried out under globally recognised standards (Figure 2.31). In addition, Bangpoo Environmental Complex can perform the incineration process for HEV batteries. Metal materials are extracted from those batteries after the incineration process and then are sent to Japan for further recycling.

Figure 2.31. Treatment and Disposal of Industrial Waste in Thailand

Waste after Incineration

Collection and Disposal of CFC

Incinerator for Batteries

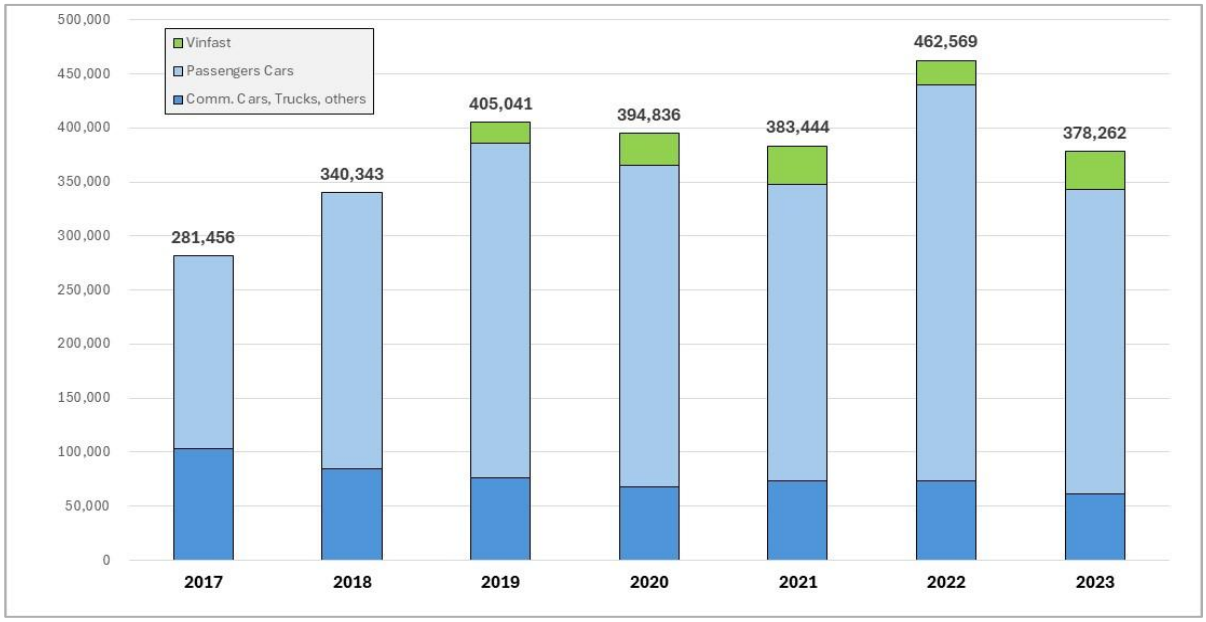
Battery Residue

CFC = chlorofluorocarbon.
Source: Authors.

2.2.5. Viet Nam

According to the Vietnam Registration Administration, Viet Nam had 3,553,700 registered vehicles as of February 2020. The number of registered vehicles in December 2016 was 2,516,144, showing a CAGR of 11–12%. New car sales in 2023 totalled 378,262, of which passenger car accounted for 84% (Figure 2.32).

Figure 2.32. Motor Vehicles Sold in Viet Nam, 2017–2023



Note: Total sales of Hyundai and VinFast on Vietnam Automobile Manufacturers' Association Sales Report
Source: VAMA, Sales Report, http://vama.org.vn/en/sales-report.html [accessed 17 March 2025].

According to the Ministry of Transport, registered EV totalled about 70,000 as of August 2024. An acceleration programme to promote green transition in the transport sector was approved in July 2022 as a part of the country's nationally determined contribution for 2030 and includes (i) improving the manufacturing, assembly, importation, and transition to electric-powered vehicles, and promoting blending and use of E5 gas for 100% of road motor vehicles; (ii) from 2025, using electricity and green energy for 100% of new buses; and (iii) from 2030, using electricity and green energy for 100% of new taxis (Government of Viet Nam, 2022a).

VinFast is the largest EV manufacturer in Viet Nam, which started operations in 2017. Vin Group has its own EV battery-manufacturing company, VinES, which develops batteries not only for vehicles but also for commercial and industrial customers. VinFast is responsible for manufacturing EV with VinES batteries. VinFast has its own factory, which is one of the largest factories and research and development facilities for EV in South-east Asia. VinFast sold 34,855 EV and 72,468 e-scooters (including overseas sales) in 2023. VinFast currently leads the sales of EV in the country.

In addition to EV, VinFast is actively engaged in the development of EV-charging infrastructure in Viet Nam. VinFast has installed charging stations in 63 provinces and is

highly active in pushing collaboration with ride-hailing services and taxis. In addition to its current EV portfolio, VinFast has started to sell mini EV (VinFast, 2023).

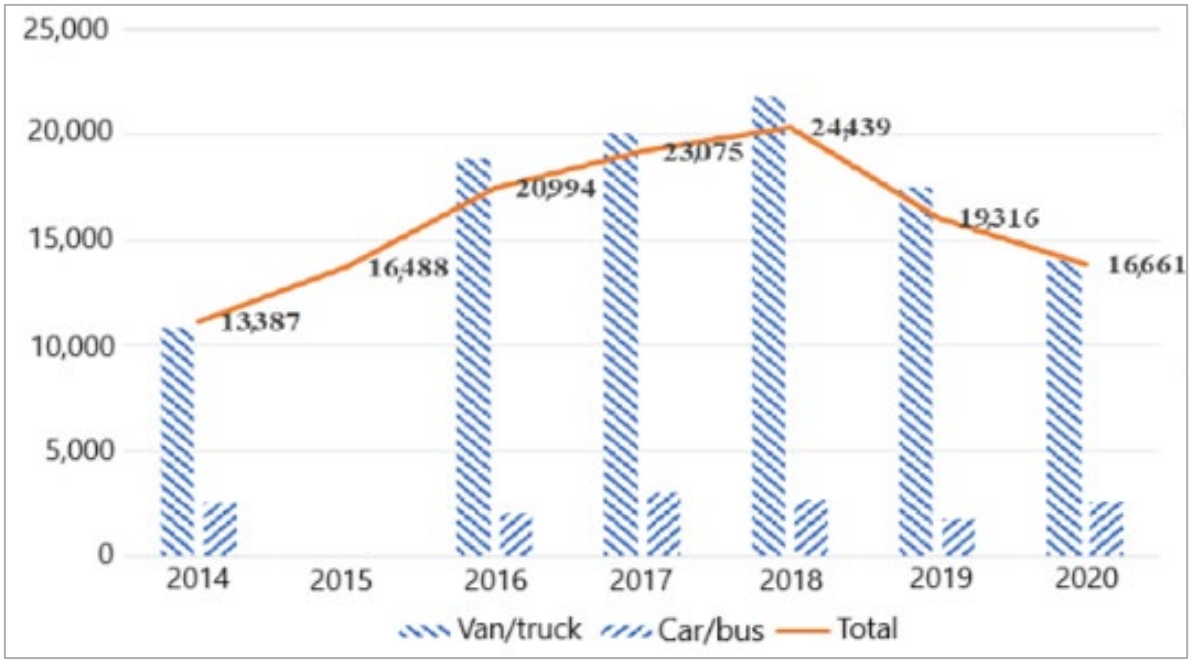
In addition, Mercedes-Benz Viet Nam launched its first luxury electric sedan, EQS, in late 2022 in Viet Nam. Mercedes-Benz plans to bring three more all-electric sport utility vehicle (SUV) models to Viet Nam, including a small luxury SUV, mid-size luxury SUV, and large luxury SUV. Other automotive brands, like Audi, BMW, Porsche, and Volvo, have introduced EV in Viet Nam or are planning to in the near future. Audi also offers fast charging at two showrooms in Ho Chi Minh City, with their new fast-charging premium lounge in District 1 being free to use. Ha Noi-based Selex Motors, a manufacturer of EV battery packs, is currently in a USD3 million convertible note investment round with ADB Ventures (Asian Development Bank's venture arm), Schneider Electric Energy Access Asia, Sopoong Ventures, and Touchstone Partners.

Battery recycling from EV is another emerging issue in Viet Nam. The e-waste management and recycling industry shows a similar structure and risk exposure as the ELV recycling industry. The majority of e-waste in Viet Nam is handled in the informal sector, famously in 'craft villages', without proper facilities and tools to treat it, resulting in significant health hazards for workers (Tran, 2018). The lack of proper legislation and management system for e-waste has resulted in authorities facing difficulties in removing waste materials from craft villages. Viet Nam needs support from other countries to strengthen its regulatory framework and law enforcement, capacity building, and technology transfer to deal with ongoing e-waste issues and upcoming EV battery waste.

Currently, VinFast and Marubeni Corporation are collaborating to promote EV battery recycling and repurposing. Both companies signed a memorandum of understanding in 2023 to utilise VinFast used batteries for energy storage systems for commercial and industrial customers, using Marubeni's expertise to efficiently utilise the used batteries. In December 2024, those companies announced a plan to move ahead with the demonstration phase.

As of 2020, there were about 222,860 ELV in Viet Nam (170,093 trucks/vans and 52,767 passenger cars/buses), which should be treated as waste and hazardous waste under the supervision of related governmental agencies (Nguyen, 2020). From 2015, the number of additional ELV has been fluctuating around 15,000–20,000 vehicles every year and is expected to rise alongside the number of registered vehicles (Figure 2.33).

Figure 2.33. End-of-life Vehicles in Viet Nam, 2014–2020



Source: Nguyen (2020).

ELV, especially passenger cars from households, were never put under the control of the government; they are mostly managed by informal private collectors, dismantlers, and recyclers (Nguyen, 2020). This situation has resulted in significant impacts on the environment and human health around dismantling sites. For instance, air samples collected in the ELV processing area of Thyen Village showed a concentration of harmful dust and chemical compounds such as halogenated flame retardants and organophosphate flame retardants and plasticisers (Takayanagi et al., 2016), indicating a higher risk of health hazards for workers in such industrial areas. Such informal activities without proper regulatory control also cause loss of natural resources through illegal dumping and destruction and exportation of parts and materials that can be recycled/reused.

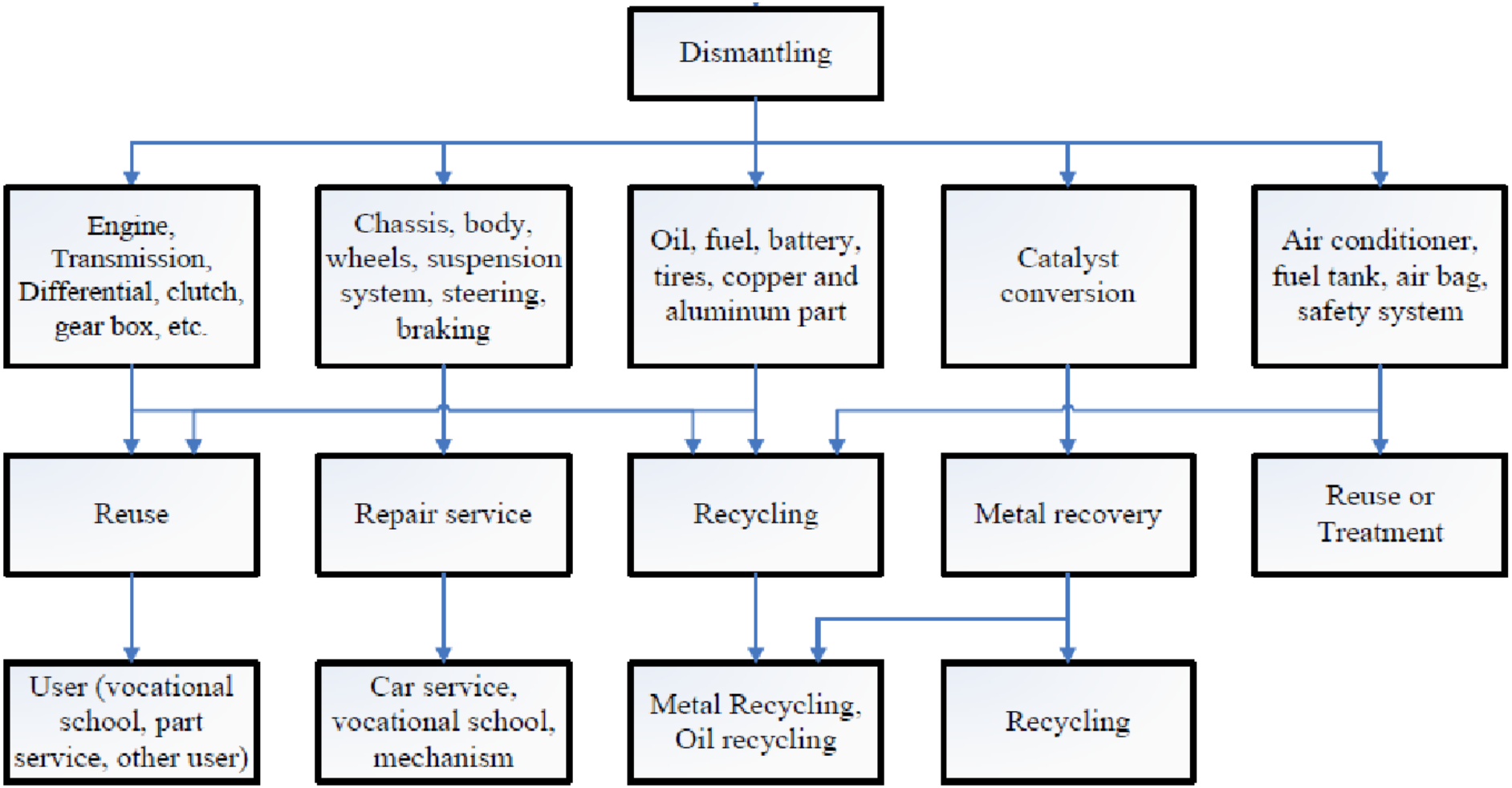
In general, the majority of ELV are handled and recycled in craft villages, located around major cities such as Ha Noi and Ho Chi Minh City. According to an interview with an expert, there are small- to middle-scale recyclers and dismantlers existing in northern areas, sourcing ELV mainly from Ha Noi and other northern cities, whereas comparatively large-scale recyclers handle ELV in the south, mainly around Ho Chi Minh City.

The field survey in Te Lo Village, Yen Lac District, Vinh Phuc Province, showed that mainly heavy construction machinery and agricultural machinery were transported, stored, and dismantled in the village. Large numbers of old passenger vehicles were also discarded there. The study team did not identify a centralised or large-scale recycling facility for passenger vehicles; three or four family-owned recycling businesses for passenger vehicles were identified. Recyclers were often unaware of the original source of the old vehicles. However, according to the field survey, sources are mainly private collectors, automobile services, driving schools, and liquidation from the Department of Transportation and Department of Public Security. The supply is stable (*Vietnam Investment Review*, 2017).

The dismantling process creates tonnes of uncontrolled waste such as grease, rust, rubber, sponges, and rags. Moreover, it generates electrolyte solution waste from discarded batteries, dust, and emissions.

Most metal parts are recycled (i.e. 80%) or reused (i.e. 20%). Plastics, composed of polypropylene, polyethylene, polyurethane, and polyvinyl chloride, have with a recycling rate of 46% and a disposal rate of 54%. Glass is reused (i.e. 49%) and disposed of (i.e. 51%). Indeed, more than one-half of an ELV (i.e. 57% in weight) can be reused, including most engine parts, wheels, airbags, speakers, chasses, and mirrors. About one-third (i.e. 32%) can be recycled as secondary material resources, including mostly metal parts, some types of plastics, and rubber. The rest (i.e. 11%) that cannot be reused or recycled is disposed of at the dismantling site (Nguyen, 2020).

Figure 2.34. Common Flow of ELV in Dismantling Centres in Viet Nam



Source: Nguyen (2020).

During the field survey in September 2024, the study team identified the current situation of recycling processes. According to several interviews with local experts, a governmental initiative is in place to prepare an industrial zone for mass recycling activities in craft villages, such as in Vinh Phuc Province. The purpose of the initiative is to introduce appropriate recycling procedures with guidelines that aim to help ensure the proper handling of hazardous waste from the recycling processes. Some regional governments are actively securing land necessary to invite informal recyclers to work in a single industrial zone as well.

Several challenges were identified, however, such as poor infrastructure to properly conduct these recycling activities due to a lack of budget. Additionally, the pandemic had a negative impact on this regional government effort, as it resulted in the reduction of the number of ELV delivered to craft villages; thus, some recyclers, who joined government-prepared industrial zones, went back to their original areas to continue their informal and traditional ways of collecting, processing, and disposing of ELV.

In Te Lo, each recycler handles a specific type of vehicle or machinery. For instance, one family-owned recycler focusses on Toyota Land Cruisers as it has a stable inflow, and the recycled items from such vehicles are normally valued high in the market (Figure 2.35).

Figure 2.35. End-of-life Vehicle Recyclers in Te Lo Village

Heavy Machinery

Dismantled Heavy Machinery

Parts from Old Toyota Land Cruisers

Recycler Handling Mainly Passenger Cars

Source: Authors.

According to interviews with a recycler that handles passenger vehicles in Te Lo, only three or four recyclers in the village focus on passenger vehicles. The reason is unclear, but one explanation is the absence of an age limit for passenger vehicles. Additionally, the amount of passenger ELV fell after the pandemic.

ELV dismantling processes in Viet Nam are mostly conducted manually without advanced tools and equipment, especially those that handle passenger vehicles. Waste treatment is not conducted appropriately. Some sites also lack necessary facilities and feature open-air garages or unpaved ground resulting in waste oil soaking into the soil. The number of vehicles processed is less than 10 per day. However, according to a local recycler, it would be easy to increase the volume by simply hiring more workers, as passenger vehicles do not require specific skills or training. In general, ELV come through individual networks; therefore, contracts are flexible depending on the relationship. Formal contracts and proof of recycling can be issued if needed (Figure 2.36).

Figure 2.36. Passenger Vehicle Recyclers in Te Lo Village

Recycling Activities

Recycler with Gloves and Sandals

Source: Authors.

Another family-run dismantler in Binh Chanh in Ho Chi Minh City, approached during the field survey, focusses on buses. Old buses are collected from domestic bus companies. The supply is somewhat stable as commercial buses have regulated age limits. Like passenger vehicles, bus dismantling does not require specialised skills; therefore, the family can handle up to 100 buses per month by increasing the number of workers. Proper waste treatment has not been implemented there, as there was clear evidence of leakage of oil onto the ground (Figure 2.37).

Figure 2.37. Bus Dismantler in Ho Chi Minh City

Recycling Activities

Dismantled Parts

Source: Authors.

A different report found that when vehicle dismantling does not require specific skills or training, it is relatively easy to locate small-scale recyclers in many different areas, presumably closer to major cities such as Ha Noi or Ho Chi Minh City, rather than locating together in a centralised craft village (Abe, 2023).

Te Lo also has experience in handling copper and iron scrap; therefore, this village has skilled recyclers for specific types of vehicles or machinery. It is more economically feasible if heavy machinery or agricultural machinery is transported in bulk to a centralised recycling area. As a result, Te Lo has become the place to handle heavy machinery and agricultural machinery rather than small passenger vehicles.

In the field survey, one recycler said that many recyclers use an online community application, Zalo, to share information on available parts for sale. As previously mentioned, more than one-half of an ELV can be reused. Residue that cannot be reused or recycled is disposed of at the dismantling site. Unusable materials that contain hazardous waste are discharged directly to the environment. Automotive shredder residue is not generated because ELV are normally not shredded in Viet Nam.

Chapter 3
Current Challenges in End-of-life Vehicle Recycling

This chapter describes the current challenges and considerations in ELV recycling laws and associated institutional systems in Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam.

Common challenges that need to be addressed in AMS include the lack of established laws and regulations related to ELV, improper ELV dismantling/recycling processes, and a dearth of advanced technologies for ELV dismantling/recycling. Due to the absence of laws and regulations, both the ELV flow and stakeholder responsibility are unclear, and there is little guidance on disposal methods and recycling procedures.

Moreover, ELV owners and insurance companies often sell their ELV to the informal sector rather than formal dismantling facilities because the informal sector can purchase ELV at higher prices. In Malaysia, experts have pointed out the necessity of incentive schemes for vehicle owners to sell to formal dismantlers and/or regulations to protect formal dismantlers. Additionally, with an expected increase in the disposal of next-generation vehicles, current workers and facilities are not well-equipped in most AMS, which will undoubtedly lead to health issues and environmental degradation.

3.1. Indonesia

There are currently no provisions on recycling and/or the management of ELV in Indonesia, and the government has failed to install Euro 4 standardisation due to public sentiment. Indeed, one study found that many citizens feel negatively towards ELV policy (Sitnjak et al., 2023), with many stating that they do not trust the government's ability to make necessary policy. The study also indicated that citizens reject regular vehicle inspections due to the lack of awareness of maintaining vehicles.

The study noted that social influence, knowledge, attitudes, institutional trust, and health issues have had a significant impact on citizens' social acceptance of ELV management (Sitnjak et al., 2023). Although the cost of a new vehicle often dissuades the recycling of an ELV, the research concluded that health issues may significantly strengthen or weaken acceptance of policies related to the environment, including ELV policy.

Most ELV dismantling operations are conducted by the informal sector in Indonesia as previously noted. Components and scraps are circulated through an informal route. Vehicle dismantling is mainly conducted by small, low-technology units with low yield and capacity.

Environmental measures – such as the prohibition on illegal dumping of waste and collection of CFC – are insufficient. Dilute sulphuric acid from oil, waste liquids, and batteries is not collected properly. Disassembling and cutting spaces are usually not covered by concrete. Dismantlers burn sheets and harnesses to remove metals, emitting CFC. Metallic component recycling is done manually, causing labour safety issues. Most dismantlers do not own machinery for dismantling due to cost. It is also challenging to

comply with international standards on ELV management.

Under Government Regulation No.101/2014, the Ministry of Environment and Forestry mandates reporting on harmful waste management. The ministry also has a monitoring team for this purpose, but its management needs improvement. The ministry recognises the importance of recycling ELV, but other issues are perceived to be more important and thus receive more attention.

As the number of EV is increasing, the associated waste is expected to be delivered to informal dismantling companies. To handle such waste safely, dismantlers must gain new knowledge and skills. However, as the informal sector does not have the funds to introduce new technology, it will be difficult to transfer the new technology for treating the waste from new types of vehicles.

The Madura and Sunda ethnic groups dominate the dismantling business in Indonesia; thus, often others are discouraged from starting businesses in the sector. It is also expected that human resources with advanced technologies to treat used EV in these dismantling companies will remain insufficient as technology may not be easily transferred.

Dismantlers need to process ELV more efficiently to reduce stock, but ELV are not disassembled without buyers. Towing fees are also a significant burden for those who want to discard ELV, as owners are often unwilling to pay the fee if the sales price of an ELV is insufficient to cover it. In such cases, owners avoid paying the towing fee by selling their cars to the informal sector (Jamaluddin et al., 2022).

During the expert meeting, the issue of used EV battery utilisation was raised. The used battery market does not exist in Indonesia. Some AMS utilise them for energy storage systems, but this is challenging for Indonesia due to transport issues. Energy storage systems are more necessary in remote areas than in cities, but moving batteries to remote areas from cities is difficult due to financial and safety aspects.

3.2. Malaysia

Malaysia's Road Transport Act 1987 requires that all commercial vehicles undergo routine inspections at car inspection centres, such as PUSPAKOM, every 6 months.[14] Previously, PUSPAKOM monopolised vehicle inspection, but the Cabinet decided to license private companies from September 2024 (Sarawak State Government, 2023). However, there is still no mandatory inspection for private vehicles in Malaysia according to MARii in October 2024.

Moreover, the *National Automotive Policy 2020* introduced mandatory annual inspections as a requirement for road tax renewal for all vehicles aged 15 years or older; presently, this is imposed only on commercial vehicles (MITI, 2020).

According to MARii, non-roadworthy vehicles (i.e. vehicles that are no longer safe enough to be driven on the road) are believed to have better-quality and reusable components compared to abandoned vehicles. MARii mentioned that non-roadworthy vehicles could be found through mandatory inspection, which could then ensure a consistent supply of

[14] PUSPAKOM, Routine Inspection, https://www.puspakom.com.my/routine-inspection/.

reusable components to the ELV recycling companies. When this supply chain is established, it is expected that the ELV industry's dependency on importing parts and components will be reduced. The implementation of mandatory vehicle inspection and an ELV ecosystem requires a concerted effort amongst relevant governmental agencies, fostering collaboration amongst OEM, inspection and services centres, the ELV industry, and public.

The importance of legal regulations concerning waste generated from ELV has also been highlighted. Sulaiman et al. (2023) insisted that AATF should be protected by enforcing proper laws and regulations to combat non-authorised dismantling facilities. This study also expressed concerns regarding the vehicle market in Malaysia, which is too large; the amount of waste from ELV may exceed the available landfill capacity soon. Thus, immediate measures are needed to increase the number of AATF.

Although AATF are promoted by the government, only two accredited facilities as of February 2025 exist. The study team had a discussion with ELV recycling stakeholders in Malaysia, who highlighted the importance of incentive schemes for companies that are interested in transforming into an AATF. The *National Automotive Policy 2020* aims to achieve a 70% recycling and recovery rate of automotive waste by implementing the AATF policy by 2030 (MITI, 2020). In addition, AATF have difficulty gaining clients, as the informal sector pays more for ELV. A financial incentive is therefore necessary to encourage owners to bring their ELV to AATF.

According to the field survey, the process of becoming an AATF is not complex; however, there are many dismantling facilities that cannot pass Department of Environment requirements. For example, one criterium is that the facility must be in an industrial area, yet many existing dismantling companies are in non-industrial areas.

The challenges of ELV recycling in Malaysia are summarised in Table 3.1.

Table 3.1. Challenges of the End-of-life Vehicle Ecosystem in Malaysia

Sector	Challenges
Political	● Lack of related policies and standards to enhance investment/support (e.g. Central Bank of Malaysia, Road Transport Department, local authorities) for increasing AATF ● Few local and international environmental agreements that impact political consideration for ELV
Economic	● Costly disposal (i.e. logistics, dismantling, recycling) with low profit margin/loss ● Poor support of ELV industry ● Lack of companies conducting environmental impact assessments in supporting the ELV ecosystem
Sociocultural	● Poor awareness of vehicle inspection ● Low incentives/penalties to encourage ELV recycling

Sector	Challenges
	● Limited access to AATF in most parts of Malaysia
Technological	● Lack of advanced technology for new-generation vehicles ● Poor compliance with international standards on ELV management ● Vocational/inspection skills required
Legal	● Lack of standardised state and local regulations and acts ● Poor compliance with related regulation/licensing (e.g. e-waste that involves the Ministry of Finance, Department of Environment, Royal Malaysia Police, and local authorities) ● Poor international standards compliance for ELV management (e.g. Basel Convention) to regulate transboundary movement of hazardous waste including ELV
Environmental	● Hazardous waste disposal (e.g. lead batteries, tires, airbags, fluids) ● Emissions from improper ELV disposal

AATF = authorised automotive treatment facility, ELV = end-of-life vehicle.
Source: Experts from Malaysia.

MARii submitted confidential recommendations to MITI on the benefits of the implementation of ELV initiatives for both consumers and automotive industry players in Malaysia. The expert at MARii mentioned that sending an ELV to an AATF benefits consumers because ELV owners do not have to deregister their vehicles themselves; instead, the AATF handles the deregistration procedure. AATF also receive fees when recycling ELV. AATF also have business-to-business arrangements with various parties such as car manufacturers, supporting industries, and the used parts industry.

Malaysia has been coordinating laws and regulations related to ELV, but again, the number of AATF is limited, and most ELV recyclers do not adhere to environmental law or guidelines, resulting in the inappropriate processing of waste. For example, engine coolants are being discharged into drains, and air-conditioning gases are being released into the atmosphere.

Abandoned vehicles are also a challenge. If an abandoned vehicle is scrapped before deregistration, the car is still in the registration system, which could affect the statistics of owned vehicles. The Ministry of Transport announced a new deregistration procedure for abandoned vehicles via the e-Dereg system on 21 March 2024 (Daim, 2024). The system allows ELV owners to deregister their vehicles through an AATF for a minimum fee. The e-Dereg programme is expected to help clear public spaces of abandoned cars, which have long caused public inconvenience, posed health risks by becoming breeding grounds for mosquitoes and reptiles, and contributed to environmental pollution through chemical seepage into the soil and groundwater. Since this programme has just begun, it is necessary to increase public awareness.

The technological challenges in Malaysia's ELV ecosystem are multifaceted. Various challenges were pointed out by the experts and stakeholders in Malaysia in the field survey, a stakeholder meeting, and expert meeting:

Lack of advanced technology for next-generation vehicle dismantling/recycling. In most cases, ELV are disassembled by hand in informal dismantling operations, and ELV processing is not efficient. Metallic component recycling is done manually, resulting in labour safety issues. The rise of EV is also introducing complexities that current ELV technologies may not fully address, as these vehicles often contain specialised components – such as high-voltage batteries and unique materials – that require advanced technologies for safe dismantling and recycling. Although one informal dismantler that the study team visited was learning dismantling methods, there is no guarantee that its ability will be sufficient for proper and safe ELV recycling and dismantling in the future.

Poor compliance with international standards. According to an expert from MARii, ensuring that ELV management practices meet international standards is a significant challenge, as Malaysian stakeholders are required to introduce high-end technology, such as catalytic converters, to extract precious materials. These standards, such as those set by the Basel Convention, regulate the transboundary movement of hazardous waste and require sophisticated technology and processes to manage ELV in compliance. Adapting to these standards often involves investing in new technologies and processes that can be costly and complex to implement.

Lack of technology integration and innovation. The sector needs to integrate new technologies that enhance the efficiency and effectiveness of recycling operations. This includes advancements in automated dismantling systems, advanced sorting technologies, and recycling processes that can handle a broader range of materials. However, integrating these technologies into existing systems and operations can be challenging and require significant investment.

No data management and tracking. An expert from MARii pointed out that modern technologies, such as digital tracking and data management systems, are essential for monitoring the life cycle of vehicles and ensuring compliance with regulations. Implementing these systems can be technologically demanding and costly but is crucial for improving transparency and efficiency in ELV management.

Unmet research and development needs. An expert from MARii pointed out that continuous research and development are needed to develop new technologies and methods for ELV processing, particularly as vehicle technologies evolve. However, funding and resources in this sector can be limited, impeding progress and innovation.

The ELV ecosystem also faces significant challenges related to human resources, which are crucial for the effective management and sustainability of the industry. Challenges pointed out in the field survey, stakeholder meeting, and expert meeting are as follows.

Large skills gaps and lack of specialised training. The evolving nature of the automotive industry, particularly with the rise of EV, requires workers with specialised skills in dismantling, recycling, and handling complex components like high-voltage batteries. There is often a shortage of trained professionals with the necessary expertise, leading to inefficiencies in the recycling process and potential safety risks. Although one informal dismantler that the study team visited was learning EV dismantling methods, technology

is evolving rapidly, and education from experts/manufacturers is needed.

Lack of vocational training and certification. An expert from MARii pointed out that there is a need for more comprehensive vocational training programmes and certification processes that equip workers with the skills required for ELV management. Existing training programmes may not be sufficiently aligned with the latest technological advancements, resulting in a workforce that is not fully prepared to handle next-generation vehicles. Expanding and updating these programmes are essential to bridge the skills gap.

Poor workforce retention and stability. The ELV industry often struggles with high turnover rates and difficulties in retaining skilled workers. Physical demands, the perceived low status of the job, and potential health risks associated with handling hazardous materials can contribute to workforce instability. Ensuring better working conditions, fair compensation, and career advancement opportunities can help retain skilled workers.

Health and safety concerns. An expert from MARii noted that handling ELV involves exposure to hazardous materials, such as lead batteries, airbags, and various automotive fluids, which can pose significant health risks to workers. According to the expert, research has been conducted on the health and safety concerns caused by ELV. Ensuring that employees are adequately trained in health and safety protocols, and providing the necessary protective equipment, is critical. However, gaps in safety training or a lack of proper equipment can lead to accidents and long-term health issues.

Slow adaptation to technological changes. An expert from MARii stated that as the ELV industry increasingly relies on advanced technologies for dismantling and recycling, there is a continuous need for workers to adapt to new tools, machinery, and processes. This requires ongoing education and training, which can be resource intensive. Additionally, some workers may be resistant to change, particularly if they are accustomed to traditional methods. According to the expert, research addressing those challenges has also been conducted.

Cultural and societal attitudes. According to an expert from MARii, there may be cultural or societal stigmas associated with working in the recycling or waste management industry, including ELV dismantling. These attitudes can make it difficult to attract new talent and can contribute to a lack of interest in pursuing careers in this field.

Addressing these human resources challenges requires a concerted effort to invest in education, training, and certification programmes; improve working conditions; and shift societal perceptions of the industry. By doing so, the ELV ecosystem can build a more skilled, stable, and motivated workforce, which is essential for its long-term sustainability. In addition, automotive associations, such as Malaysian Automotive Association, may have a role to play in supporting human resources and industries; however, there are more than 80 such associations in Malaysia, with none tagged to tackle such challenges.

Public awareness of the ELV issue should be raised as well. Through an interview with an informal dismantling company, it was found that many Malaysian people do not know how to dispose of ELV appropriately. Many keep ELV for a long time. Experts at UKM mentioned sentimental issues regarding ELV in Malaysia; some vehicle owners do not want to admit that their cars are old enough to discard. These experts also pointed out that vehicle prices are increasing, so many vehicle owners want to use their vehicles as long as

possible.

3.3. Philippines

In the Philippines, private vehicle deregistration and renewal are not explicitly based on vehicle age or type but are usually based on emissions testing results. However, many emissions centres issue results without proper testing, as proper inspection often cannot be carried out due to a lack of equipment. Many stakeholders also pointed out that there is no incentive to stop the use of old cars. Vehicle owners keep their cars in their garages even after the cars are no longer working because they are sentimentally attached to them.

In the field survey, a dismantler pointed out that following the yearly changing hazardous waste regulations is challenging. Also, the dismantler highlighted that insurance companies are willing to sell accident-wrecked cars to informal dismantlers; they can offer more money for them because they do not invest in environmental protection equipment.

In the field survey in *Barangay* Tatalon, the importance of official documents was highlighted. Dismantlers are supposed to receive a validated OR/CR before dismantling a car, but many illegally dismantle cars without these documents in the evening. How to monitor and to control the documentation of registration is a challenge for ELV recycling in the Philippines.

According to local experts, regulations on ELV are premature in the Philippines. First, the country should establish a scheme to promote ELV recycling. Infrastructure is also insufficient. En Tsumugi highlighted that it is facing competition from informal dismantlers that do not care about environmental pollution, as there are no policies for proper disposal of ELV.

As ELV are recycled mainly in the informal sector, the flow is not clear. Some informal recyclers are illegally obtaining ELV. In the field survey, a dismantler pointed out the problem of waste oil disposal, as many dismantlers simply leak it on the ground. The ERIA study team noticed that the sidewalk, where many informal dismantlers work, was covered with the leaked oil and melted plastics from the dismantling process.

The dumping of residue is also another problem. The ERIA study team found that one recycler removes plastic covers with nippers and then salvages the metal parts, dumping the plastic covers. Also, some informal recyclers associated with junkshops along Zamora Street in Manila burn electric cords in a metal basket to remove the plastic coating, causing air pollution.

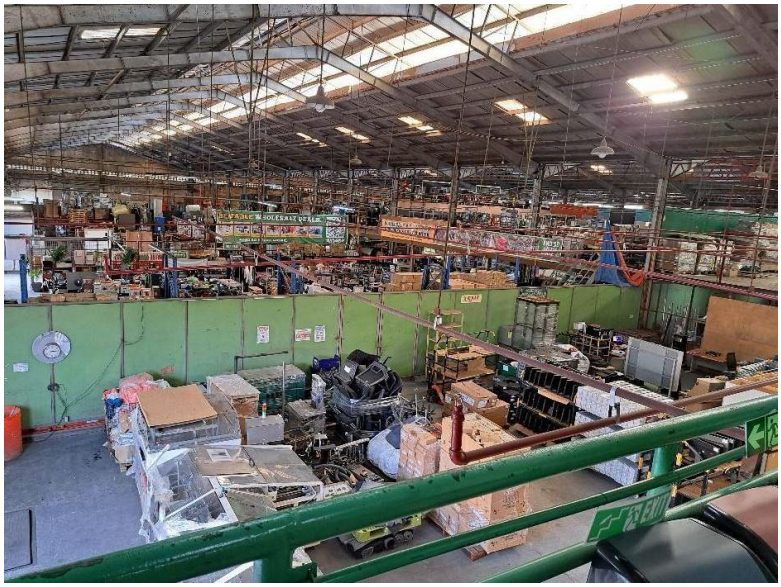
En Tsumugi also highlighted that while it receives some invitations to collect ELV, such ELV are very old, around 50 years. For example, when a grandfather passes away, his car is left in a garage, and his family asks En Tsumugi to dispose of the car. In this case, who has the right to dispose of the car is the issue. Registration of the car is often expired, and ownership is still in the name of the person who is now deceased, with no proper documentation of inheritance. The disposal of the car for proper ELV recycling is hindered by this technicality of legal ownership.

En Tsumugi also needs information on how to properly estimate the cost of its dismantling services to customers; however, it is difficult to establish proper pricing. If a

database for ELV and used parts valuation for proper dismantling is standardised in AMS, such a database would be useful for ELV recyclers.

Some large dismantlers are well-equipped with facilities for safety and environmental protection. For example, Envirocycle, an e-waste dismantler that has experience in ELV dismantling, established a sophisticated scrap segmentation and waste management system, compliant with domestic and international standards (Figure 3.1).

Figure 3.1. Envirocycle Factory, Philippines



Source: Authors.

On the other hand, informal dismantlers dismantle ELV without infrastructure or gear for proper disposal of scrap waste and dangerous substances (Figure 3.2).

Figure 3.2. Informal End-of-life Vehicle Dismantling along Zobel Roxas Street, Manila

Source: Authors.

Advanced technologies require much investment. Balancing a high level of technology with economic viability is a challenge. Experts pointed out the importance of transforming informal sector dismantlers to formal dismantlers step by step.

In the field survey, a dismantler highlighted the challenges caused by vehicle technology development. Vehicle components are changing, such as more electric parts being installed in new cars. According to a second-hand parts importer from Japan, the importation of ICE from Japan is getting more difficult. In the Philippines, some parts from old Japanese ICE vehicles are no longer available through second-hand markets in Japan, as EV now dominate the market. Thus, it is exploring the importation of ICE from other AMS.

Appropriate treatment of CFC and HFC is important for the Philippines, but collection and treatment schemes are premature. Only one company, Delsa, has a licence for collection. A Japanese company, Marubeni, is planning to launch a treatment plant soon.

Currently, dismantlers are not concerned about environmental issues. It is still indispensable, however, to train workers on ELV recycling and management of hazardous waste. Also, experts in the Philippines pointed out the importance of changing vehicle owners' mind-set. Owners want to keep very old cars that do not meet environmental standards and sometimes after they stop running.

The Department of Transportation is promoting the Public Transport Modernization Program, which aims to replace old jeepneys (i.e. four-wheel diesel engine vehicles). The

number of vehicles that should be replaced was estimated at 127,000 in June 2022. Moreover, the government is beginning to certify recycling facilities for these vehicles, including disposing of residue like batteries and CFC (DOT, 2020). As of 1 February 2025, the sole treatment, storage, and disposal facility has been issued a certificate for authorised dismantling, but it has not yet started operations.

The modernisation of jeepneys also requires a new set of skills for vehicle repair mechanics. Policymakers are pushing for Euro 4 engines to replace the old diesel engines. However, Euro 4 engines are equipped with electronic control devices, which need additional technical and computer skills. Currently, most jeepneys use Euro 2 engines, which do not have such devices. Most jeepney mechanics do not know how to install or repair Euro 4 engines. The government is providing a training programme for this new skill, but uptake has been slow.

3.4. Singapore

Boosted by tax incentives and rapid infrastructure development since 2020, the number of EV in Singapore surged from 1,809 in 2019 to 33,562 in 2024.[15] The increasing number has led to concerns regarding recycling. Many researchers are working on new technologies to efficiently recycle resources from EV, especially batteries. Furthermore, Singapore introduced an EPR scheme on e-waste in 2021, which requires electronic goods producers and retailers to recycle their products when they are disposed of. Meanwhile, increased governmental and corporate accountability – including full implementation of the EPR law and more investment into upcycling innovations – have been critical in creating a more sustainable waste management ecosystem in Singapore.

Singapore, like many other countries, is impacted by the complexity and strictness of regulations surrounding ELV recycling. The regulatory framework must balance environmental concerns with industry capabilities, often requiring significant updates to keep pace with technological advances in vehicle manufacturing and disposal techniques. For instance, the European Union has recently updated its ELV regulations to include more stringent requirements for recycling efficiency and EPR. The introduction of the EPR scheme on e-waste in Singapore reflects this same direction. Another key challenge is how to implement a policy that places the responsibility of collection and proper treatment of waste on producers (Begum, 2022).

Despite the potential for producers to creatively and innovatively increase their waste collection goals, there is a risk that the waste may not be effectively recycled nor repurposed. Therefore, it is crucial to provide clear and verifiable data on waste collection and to prevent the misuse of this policy as a 'greenwashing' tactic, ensuring the comprehensive and effective implementation of EPR.

A significant portion of Singapore's recycling is exported to countries such as Australia, China, India, Indonesia, Malaysia, South Korea, and Thailand for processing. However, recent policy changes in China and Indonesia to reduce imported waste have led to a rise in the incineration of Singapore's recyclable materials. Many industry specialists argue

[15] LTA, 'Statistics about Motor Vehicles', https://www.lta.gov.sg/content/ltagov/en/who_we_are/statistics_and_publications/statistics.html [accessed 10 February 2025]

that establishing a domestic recycling operation in Singapore is not economically viable, and there is limited transparency around the fate of exported recyclables (Trang, 2021). In contrast, Japan and South Korea illustrate exemplary practices in ELV recycling, with advanced systems ensuring proper dismantling of vehicles and safe removal and treatment of hazardous substances. Japan has enacted legislation to ensure high recycling rates for materials like airbags and other vehicle components, supported by a well-coordinated industrial structure involving manufacturers, dismantlers, and recyclers.

Singapore is striving to become a zero-waste nation as it deals with the global challenge of managing growing waste volumes. The *Sustainable Singapore Blueprint* emphasises the development of efficient waste collection, management, recycling, and disposal systems (MEWR, 2009). Given its status as an affluent, highly urbanised country with limited land availability, Singapore relies heavily on four waste-to-energy plants to incinerate non-recyclable waste. The ash from incineration and non-incinerable waste is stored at its sole offshore landfill on Semakau Island, which is projected to reach capacity by 2035, 1 decade earlier than initially estimated. The growth in population and wealth of the city-state is expected to increase future waste generation as well. In 2018, Singapore produced 7.7 million tonnes of waste, with 60% recycled and 40% either incinerated or landfilled (Kerdlap, Low, Ramakrishna, 2019).

On the technological front, advancements are continually needed to handle newer materials used in vehicles, including electronics and EV components. Learning from international best practices and continuing to innovate in technology and public engagement are key steps towards improving the situation.

A significant challenge in enhancing ELV recycling rates in Singapore is public awareness. Despite proactive measures to improve recycling, there remains a general lack of education and engagement amongst the public regarding proper recycling practices. This is evident from the overall low domestic recycling rates and the observation that proper recycling habits, such as adequately preparing materials for recycling, are not widespread.

Vehicle scrapyards in Singapore play a vital role in the country's efforts to promote sustainability and to reduce waste. By recycling ELV, these facilities help conserve valuable resources and reduce the environmental impact of mining and manufacturing. As the number of vehicles registered in Singapore doubled from 2014 to 2016 and remained at a high level until 2019, it is likely that the demand for vehicle scrapyards will also increase in the next 5 years. Furthermore, the registration of EV increased sharply in these years; by investing in advanced recycling technologies and processes for EV, the industry can continue to meet this demand in a responsible and sustainable manner.

Overall waste management in Singapore is also a vital issue. Singapore has addressed waste management issues by increasing recycling rates from 47% in 2003 to 60% in 2018. Nevertheless, the overall generation of waste has climbed, resulting in little progress in reducing the volume sent to incinerators and landfills (Kerdlap, Low, Ramakrishna, 2019). Household recycling rates remain low. Despite efforts to promote a 3R approach and declaring 2019 as the 'Year towards Zero Waste', the domestic recycling rate fell from 22% in 2018 to 17% in 2019, with only 4% of plastic and 18% of food waste recycled (Trang, 2021).

3.5. Thailand

One of the key issues is the lack of regulations for organised and comprehensive ELV management in Thailand. For example, Thailand has established a car inspection system, but the study team identified that rigorous implementation of the system is not assured. Inspectors can provide guidance to car owners to replace faulty devices with new ones, but to avoid arguing with the owners, guidance is often not voiced. Even if equipment is broken or the licence plate is missing, car owners can easily pass inspection. This leads to the circulation of old cars, which threatens safety and the environment.

Moreover, there are no regulations on how vehicle owners should proceed with cars that are no longer in use, including the absence of vehicle tracking and data collection systems for unused vehicles. When a vehicle reaches the end of its useful life, the owner has the option of scrapping it or simply selling it to the informal sector. According to Kriengkrai, Homklin, and Phamaranon (2019), many owners are choosing the second option, and DLT has no regulations for car owners to deregister them. The absence of a clear and standardised system for ELV collection, dismantling, and disposal often results in haphazard practices, including illegal dumping and informal dismantling operations, as well as poor data.

Another major challenge is the lack of enforcement of existing regulations. While there are laws in place that require the proper disposal of hazardous materials, according to an interview conducted during the field study, these laws are not strictly enforced, leading to widespread non-compliance. Meanwhile, dismantling is mostly done by hand, and CFC and waste oil are not properly disposed of, endangering both the environment and worker safety. If current practices in Thailand remain unchanged, various health and economic problems will be at the forefront. According to Thanakorn Wangboonkongchana, a government spokesperson, the Prime Minister expressed concern that old vehicles will contribute to dangerous fine particles or harmful air pollutants (*Bangkok Post*, 2022).

The process of ELV recycling in Thailand faces significant challenges due to the unstructured nature of the recycling industry. It occurs through a market mechanism of reusable parts or recyclable resources recovered from ELV, without taking into account waste disposal and environmental measures and their costs, according to the field study. It is thus necessary to thoroughly consider (i) who will bear the new cost burden and (ii) how in the flow of ELV discharge, recovery, dismantling, recycling, and proper disposal.

To implement sustainable recycling and proper disposal of ELV, it is necessary to clarify the roles and responsibilities of manufacturers and importers, dealers and other distributors, users, collection and dismantling companies, and related entities such as the government. One option could be to establish a system where distributors are obliged to collect a recycling fee from users, and a fee is provided to the recyclers when the vehicle is recycled properly.

Furthermore, there is no standardised procedure for the collection and segregation of ELV, which results in a low recovery rate of valuable materials. The absence of streamlined processes leads to inconsistencies in the quality of recycled materials, thereby reducing their market value and utility in manufacturing new products. It also results in significant economic losses for Thailand. According to Mangmeechai (2022), many ELV are discarded annually, and very few are sent to recycling facilities. The value added in ELV management could be THB58 million–THB92 million per year if these ELV

parts are properly recycled (Mangmeechai, 2022).

Additionally, ELV are the only source of reusable spare parts. With the increase in the number of vehicles becoming ELV – as well as the increase in vehicles that need to be repaired after a disaster or accident – it is expected that the number of users for these reusable spare parts will increase. As a result, the used spare parts industry has high potential for increasing economic growth while also creating job opportunities (Jamaluddin et al., 2022) However, a well-organised process of ELV recycling with a clear value chain of recycled parts and a positive employment environment are necessary for this to occur.

Adoption of advanced technology in the ELV recycling sector in Thailand is not common. In the field survey, it was found that most recycling facilities lack the technologies for efficient dismantling, material separation, and recovery, although some companies are equipped with recycling technologies that align with global standards. This technology gap results in inefficiency of ELV dismantling for most dismantlers in Thailand and will be problematic if the number of ELV increases, accompanied with the fast growth of the automobile industry in Thailand. Expanding this infrastructure is critical to improving the overall management of ELV residue.

Furthermore, according to the interview with stakeholders, there are only few companies in Thailand that possess the technology to handle the disposal of CFC, liquid waste, and other hazardous materials related to dismantling ELV. Introducing adequate infrastructure for the safe handling, dismantling, and recycling of ELV is key.

The ELV recycling industry in Thailand also faces significant human resources challenges, primarily due to the lack of a formally trained workforce. Although there is a huge network of informal sector players, workers in this sector typically have limited opportunities to learn standardised skills, which affects their efficiency and the overall safety of recycling operations, according to the field study. There is also a significant turnover rate, which can disrupt the continuity of operations and lead to knowledge loss.

A lack of awareness of car users is another significant impediment to the development of proper ELV management systems. Awareness and educational campaigns have been initiated in Thailand to inform vehicle owners about the importance of properly disposing of ELV, but it will not be sustainable without a constant income stream. To properly and successfully manage ELV, vehicle owner willingness to pay is key. The ELV Recycling Law in Japan, for example, requires vehicle owners to pay recycling fees. Towing fees – not to mention recycling fees – could be a significant burden for the vehicle owners in Thailand.

There is a need to enhance awareness and understanding amongst vehicle owners regarding the proper disposal of ELV. As a starting point, the government should provide information on the impacts of ELV, leading to improvement of their knowledge and an increase in motivation of the population to participate in recycling programmes.

In the future, huge numbers of cars will reach the end of their lives and will require proper management. Problems arising from ELV could soon endanger the environment, economy, and society in general. According to the Land Transport Department, there are more than 5.03 million vehicles over aged 20 years registered on the road as of 31 January 2022, and this number is expected to rise to 16.00 million over the next 20 years if serious ELV recycling action is not taken (*Bangkok Post*, 2022).

Other challenges include the market mechanism of recycling ELV on which Thailand has relied. The fluctuating prices of raw materials are also impacting the profitability of recycling operations. The market for recycled materials is often volatile, and without stable demand, recyclers face financial uncertainty.

3.6. Viet Nam

While the Environmental Protection Law of 2005 broadly delegates the responsibility of recovering expired or discarded means of transport to owners (Article 67, 1.a), there is still no existing regulation specific to the management of ELV and/or vehicle recycling in Viet Nam, which includes the absence of legal documents specialised for e-waste and environmental measures such as a prohibition on illegal dumping of waste and mandatory collection of CFC (Kojima, 2018).

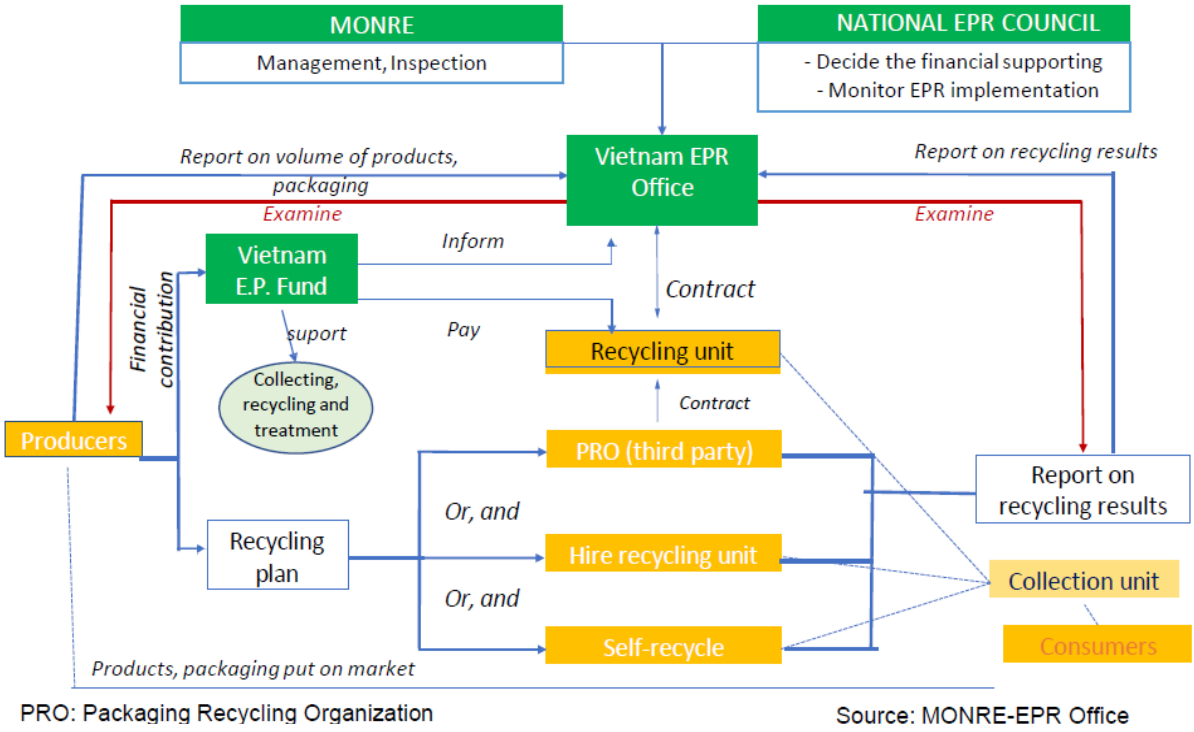
As of 2020, Viet Nam is not prepared to receive and to manage a flow of waste from ELV, both from a technical and legislative viewpoint. Thus, it is crucial for the government to improve the legislation and management infrastructure for the application of an EPR system to manage this type of waste (Nguyen, 2020).

Currently, the government is accelerating its effort to upgrade EPR for ELV, shifting from a voluntary to obligatory framework. Decree No. 02/20022/ND-CP and 08/2022/ND-CP were issued to introduce updated EPR as an obligatory framework, where six different product groups are covered: packages, batteries, lubricants, tires, electrical products, and transport vessels. Obligatory recycling is applicable to packages, batteries, lubricants, and tires from January 2024 onwards, while that for electrical products is in effect from January 2025, and for transport vessels to be in effect from January 2027.

For transport vessels – including passenger vehicles and motorcycles – draft recycling rates and specifications are defined in an annex of Decree No. 08/2022/ND-CP, where the recycling rate is kept around 0.5–1.0%. According to the results of the field survey, the purpose of the relatively low recycling target is to test the recycling market for automobile producers/recyclers with an obligatory framework. The rate can be revised 3 years after the implementation of EPR for the vehicle industry. Additionally, MONRE is preparing an updated guideline for vehicle recycling to be issued in January 2025.

In terms of the recycling cost, currently, recyclers have two options when disposing of ELV. One is to submit a recycling plan and to process ELV according to appropriate measures at the producers' own cost. This procedure is further divided into three options: (i) hiring third-party recyclers, (ii) hiring necessary recycling units and facilities, and (iii) recycling on one's own. The other option is to make a financial contribution to the Vietnam Environment Protection Fund (Figure 3.3).

Figure 3.3. Extended Producer Responsibility Mechanism in Viet Nam



EPR = extended producer responsibility, MONRE = Ministry of Natural Resources and Environment, PRO = packaging recycling organisation.
Source: EPR Office, https://epr.monre.gov.vn/

As mentioned, the government has already commenced work on an updated EPR framework for packages, batteries, lubricants, and tires. In the meantime, there are several arguments and challenges on the feasibility of EPR identified through the study team's research and the field survey. Key challenges include an absence of clear guidance for recycling costs, lack of effective support to promote the recycling market, and lack of adequate infrastructure to process recycled materials, which indicates a need to build a capacity to effectively enforce the updated EPR (*Vietnam News*, 2024). This indicates that the government must provide necessary support, such as information on adequate recycling operators or units on the government's platform to be easily accessible by producers to follow their recycling plans. Producers have difficulty understanding the need to switch from traditional recycling measures to proper ones; they also tend to avoid a financial contribution to the Vietnam Environment Protection Fund as the purpose of the fund is not well understood.

Similarly, recycling of two-wheel motorcycles has encountered challenges. According to the field survey, it is common to see motorcycles piled up at police stations (Figure 3.4). This is because buying another motorcycle is often cheaper than paying the penalty when motorcycles are confiscated. Thus, a significant number of motorcycles are kept in storage without being recycled.

Figure 3.4. Abandoned End-of-life Vehicles in Viet Nam

Abandoned Motorcycles at Police Station

Old Motorcycle Storage in Te Lo

Source: Authors.

Kojima (2018) identified key challenges in ELV processing, including poor separation at source, lack of a large-scale centralised treatment complex for industrial solid waste and hazardous waste, and small-scale and spontaneous recycling activities that are difficult to control. The field survey confirmed that these challenges remain in Viet Nam.

Dismantling is commonly done by the informal sector, and components and scraps are circulated through an informal route. Although proper waste oil recyclers are present, a mechanism that ensures the flow of waste oil to proper waste oil recyclers is still not well established. Additionally, due to the lack of processing facilities, CFC are released into the atmosphere without being properly recovered.

Considering that the dismantling process in craft villages such as Te Lo is common in Viet Nam, many environmental issues has been found by Ehime University, especially problems related to hazardous matters including heavy metals and persistent organic pollutants (Takayanagi et al., 2016). With more ELV expected to be generated in the future, Viet Nam will have to create private dismantling sites if proper infrastructure for an ELV management system is not prepared.

Additionally, the cost of recycling is a challenge for craft villages. Many recyclers in craft villages are afraid of limiting their profits by implementing legal and formalised recycling measures or by required investment in facilities. In the field survey, several stakeholders called for improving the situation such as by increasing the volume of ELV in specific craft villages with governmental control. However, current law strictly limits the importation of second-hand vehicles to those less than 5 years from their original usage; therefore, the government must make ELV recycling an industrialised activity with standard measures and on an economically feasible scale.

During the field research at Te Lo, the study team identified most recycling activities were still handled manually, especially for small passenger vehicles as these vehicles do not require specific skills or tools to dismantle. Informal dismantling process in craft villages causes serious impact on human health. The study team identified the recyclers for

passenger vehicles at Te LO are dressed casually and handling ELV in their home yards. Workers wear gloves and sandals; goggles are not usual.

Overall, rapid economic growth in the country is accelerating the flow of ELV into the informal sector. A similar case is foreseeable for EV with Viet Nam's ambitious target to introduce EV in public transport without a proper framework to recycle the old vehicles.

Chapter 4

Recommendations for Proper Processing of End-of-life Vehicles and Development of Relevant Legislation

4.1. Summary of Trends and Issues

The trends and issues for ELV recycling from the survey are summarised in Figure 4.1.

The number of cars is increasing in AMS, which will make the number of ELV grow as well.

Vehicle inspection is a key instrument to mitigate and to prevent air pollution from vehicles with poor exhaust systems and to promote appropriate recycling with more reuse of parts. It can also help prevent the illegal dumping of ELV. However, insufficient implementation of adequate vehicle inspection is a common challenge in AMS. Old cars with poor exhaust systems continue to be used in AMS, as little incentive exists to replace old cars with new ones. No age limit exists for private cars, while it is set for commercial vehicles in some AMS.

The importation of used cars is also problematic in AMS. In some, second-hand cars are imported that do not meet adequate environmental standards. The exportation system is more unclear, but if semi-finished parts of used cars are exported, the recipient country – often lower-income countries in AMS and in other areas such as Africa – faces further difficulties in determining whether their performance is guaranteed.

ELV recycling dominated by the informal sector is a significant issue. Many are recycling ELV without appropriate protective gear such as masks and gloves, endangering their health. Moreover, negative environmental impacts from informal ELV disposal and recycling have been reported, but these are not yet widely recognised as dangerous by the public. Formal, advanced, and/or authorised dismantling companies have emerged but are struggling to collect ELV due to competition from the informal sector. Vehicle owners and insurance companies tend to sell their vehicles to the informal sector, as it buys vehicles at higher prices. It prioritises economic profit over environmental responsibility.

EV are becoming more popular in AMS, causing more recycling issues. More digital equipment is being installed in new types of vehicles, exemplified by advanced exhaust control systems, connected cars, and driver-assistance systems. Some EV manufacturers have started testing battery-swapping systems and development of swapping stations within ASEAN. Yet different recycling processes are required for EV and ICE vehicles; as for HEV, some dismantlers have started to learn new dismantling processes, but standards and capability vary greatly.

Figure 4.1. Issues for End-of-life Vehicle Recycling in ASEAN

ELV = end-of-life vehicle, EV = electric vehicle, JICA = Japan International Cooperation Agency, HEV = hybrid electric vehicles.
Source: Authors.

Appropriate battery recycling will become a key challenge in line with EV penetration, as huge amounts of waste batteries are expected to be generated in the future. Material from lithium-ion batteries is classified as hazardous waste, and sophisticated safe recycling

technologies and processes are required. Keeping the capacity and safety of used EV batteries for reuse is becoming an issue, especially for exportation.

To improve the ELV recycling procedure, it is important to analyse the status quo. Currently, the generation of ELV is increasing, but no official statistics for ELV exist in AMS, making it difficult to understand the nationwide situation. Many AMS do not have a tracing system (e.g. the manifest system in Japan) after vehicle owners stop using vehicles.

The development of laws and regulations is also a major challenge. Due to the lack of laws and regulations, the flow of ELV vehicles and the responsibilities of the actors in the ELV industry are unclear, and there is a lack of guidance on disposal methods and recycling procedures.

4.2. Policy Recommendations

Recommendation 1: All AMS should establish legislation or systems on appropriate ELV dismantling and recycling in consideration of their own national circumstances in terms of the economy and capability.

Some AMS are currently pursuing different approaches to improve ELV dismantling/recycling. Malaysia has developed several standards for ELV dismantling/recycling. The Philippines is focussing on dismantling/recycling of public transport vehicles and has implemented regulations on their proper recycling. Thailand has started a consideration process on the development of ELV-specific legislation, with support from JICA. Viet Nam established the EPR Act, and EPR on vehicles will be implemented from 2027.

The appropriate approach depends on the national circumstance of each AMS, including economic situation, capability, politics, and pathway of ELV dismantling/recycling industry and surrounding industries such as the steel and smelting industry.

Recommendation 2: Vehicle owners should be encouraged to replace old cars with poor exhaust systems with new ones with good exhaust systems. Strict implementation of inspections is thus necessary to secure the performance of exhaust systems and the safety of the vehicles on road. Setting a maximum age limit for passenger vehicles could also be considered.

Some experts invited to the expert meetings for this research, as well as many interviewees in the field surveys, stressed the importance of changing the mind-set of stakeholders towards ELV. Many people believe in keeping vehicles too long, so awareness-raising campaigns endorsed by the government, car manufacturers, and importers are very important.

However, this attitude is also caused by the lack of incentives for car owners to replace old cars, even if the old cars have poor exhaust systems and low fuel efficiency, contributing to high air pollution in many ASEAN cities. Some also believe that long-term car ownership is rewarded through tax deductions. Cars are viewed as family assets; in some cases, car owners keep their cars in garages or yards even when they are no longer working. One expert for this survey pointed out that if the ownership of an old car is not

transferred to heirs and the car owner dies, the disposal process becomes more complicated and difficult. When such a situation occurs, an ELV may not make its way into the ELV recycling ecosystem.

A measure to prevent such a situation is periodic vehicle inspection. If this is implemented appropriately, it could ensure safer cars, maintenance of emissions standards, and provision of a constant supply of ELV to the recycling ecosystem. Periodic inspection could also be a means of letting vehicle owners know that their vehicles should be deregistered. Strict enforcement is needed, and all vehicles – both private and commercial – should be subject to inspection.

Setting the age limit of vehicles is also important for safety. In some AMS, the age limit for commercial vehicles ensures the regular renewal of trucks on the road.

It is also important to have a clear international definition of the vehicles to be discarded. This would help avoid the importation of ELV, for which quality control is difficult. In the Philippines, vehicle frames, including some parts for light passenger vehicles, are imported from other countries and reassembled/remanufactured locally. An expert pointed out concerns regarding the quality control and safety of these vehicles. Another pointed out that if the vehicles include hazardous waste, there is a possibility of violating the Basel Convention.

Recommendation 3: Current efforts to develop a licence scheme for recyclers with appropriate measures and facilities (e.g. Malaysia, Philippines, and Viet Nam) should be encouraged and strengthened. Licence schemes should include tracing mechanisms for ELV and materials for recycling, collection and reuse of batteries, and the appropriate disposal of automotive shredder residue (ASR), chlorofluorocarbons (CFC), waste oil, and other waste generated from the dismantling process. Any priority measures for licensed recyclers should also be considered.

There is little incentive for informal dismantlers and recyclers to become formalised in the ASEAN region, because their businesses are currently profitable.

The survey found that many informal dismantlers are causing environmental problems, however. Waste oil is often not collected and penetrates the soil, for example. Such negative environmental effects are not widely recognised in AMS. In addition, advanced technologies with safety measures to efficiently recycle ELV have not been widely adopted, despite the increasing numbers of ELV.

To promote environmentally friendly ELV recycling, licence and/or regulation mandates for ELV recyclers should be introduced, as implemented in some AMS (e.g. Malaysia and Philippines). Support from international stakeholders with experience in installing and implementing ELV recycling policies is necessary for such policy formulation. Cooperation from international organisations may be necessary. For example, in Indonesia, a project funded by the Global Environment Facility Trust Fund has proposed a draft concept of e-waste treatment and specific treatment of batteries to the Ministry of Environment.

In addition, investment and/or support from the government and private sector are necessary for ELV recycling facilities to improve their infrastructure to comply with regulations to obtain formal licences. The study team found that most informal

dismantlers do not have the proper equipment for recycling activities and that their facility sizes are often smaller than the licensed ones. Some AMS have made investments; for example, in Singapore, there are authorised scrapyards and recycling facilities that have support from government and private sector investments for efficient and environmentally friendly processes. In Malaysia, the Department of Environment is issuing AATF licences to ELV dismantling facilities that comply with requirements (e.g. facilities with gradient level floors and scheduled waste storage rooms). In addition, the Ministry of Industry in Thailand is implementing a pilot project to establish an efficient and appropriate ELV resource circulation system with the aid of the Government of Japan.

Some experts and interviewees for this survey pointed out that the number of facilities that conduct proper recycling is still insufficient in AMS. To increase their number, it is important to maintain their profitability. Therefore, priority allocation of specific ELV to licensed dismantlers/recyclers should be done in some AMS (e.g. accident cars from insurance companies or public transport vehicles). Maintaining a steady ELV supply would be a way to sustain their profit.

Recommendation 4: For second-hand parts, quality guidance and test measures for reuse, repurpose, and refurbishment should be established. Especially for used EV batteries, a battery passport system should be established for proper management.

Most ELV dismantlers in the region take used parts from ELV to sell them as second-hand parts to car maintenance shops (i.e. workshops) or car owners. However, in many cases, the quality of the parts is not guaranteed. Some ELV dismantlers provide quality assurance by taking back parts within a few weeks if there is a problem.

AMS should encourage communication and collaboration to establish common standards and cross-regional rules for ELV recycling, including EV and used batteries. This can help promote the recycling industry by assigning roles and responsibilities as well as improving the traceability of recycled materials between AMS.

Recently, EV have become popular in AMS. To reuse and recycle EV batteries, testing and quality assurance are important. In an expert meeting, one expert highlighted the importance of standardising the testing of used EV batteries. A rule defining the state of health of a battery is currently under discussion amongst AMS and will be implemented in the future. If, after about 10 years of use, the capacity of a battery is below the standard of health compared to the initial capacity, the battery cannot be reused in vehicles but can be used in an energy storage system.

The European Union introduced the Battery Passport system in 2023 to track the status of batteries from the start of their use in new vehicles until the end of their lives. This system requires information on the material of the batteries, manufacturer, and place of manufacture, so that users and recyclers are informed. Standardisation of a similar system amongst AMS could help improve traceability.

The inspection of EV batteries should be promoted throughout ASEAN, as the continued use of damaged/degraded batteries is dangerous. Research and development are required to improve detection of damaged/degraded battery cells. These should be conducted with collaboration amongst AMS.

Recommendation 5: Capacity building regarding ELV in central governments and local governments is necessary.

Capacity building of knowledge about environmentally friendly ELV processing and practical methods is necessary for ELV recyclers; international stakeholders could help develop and run such training programmes. In addition, training programmes supported by non-AMS are recommended to leverage available knowledge and experiences accumulated in those countries (e.g. Malaysian automobile companies participated in a training programme in Japan provided by JICA, and the Government of Thailand is currently working with JICA to prepare a legal scheme for ELV recycling).

Dedicated personnel and teams should be organised to improve public awareness of recycling measures and related policy updates through information sharing or any knowledge platform. Detailed manuals, procedures, and guidelines should be made more accessible through information platforms, especially after the establishment/updating of recycling regulations such as EPR. Viet Nam has implemented EPR, but not enough information is available on it on the government platform, for example.

Collaboration amongst the central government, local governments, and the private sector should be strengthened. Recycling activities involve the informal sector, so central governments should maintain a dialogue with these actors through local governments and civil society organisations. Communication channels between government authorities and vehicle manufacturers (including overseas manufacturers) should be developed and made more visible.

Closer communication or recycling partnership amongst AMS should be considered to share each country's strengths and key challenges. This will contribute to bringing in a collective approach to improve the ELV recycling industry in the entire ASEAN region as well as liquidity in recycled materials and critical minerals from batteries.

Recommendation 6: Non-AMS should support AMS efforts to establish legislation or systems on appropriate ELV dismantling and recycling.

While an appropriate approach to improve ELV dismantling/recycling depends on unique national circumstances, support from non-AMS by sharing their lessons learned with AMS could provide a pathway for the development of ELV legislation or system in an AMS. Thailand, for instance, has begun a consideration process on the development of ELV-specific legislation with a technical support from JICA.

Vehicle inspections, financial incentives to replace old cars, standards of dismantling/recycling, and guidelines for testing used automotive parts before sale could be references beneficial for AMS to realise how to implement ELV legislation or system effectively and smoothly. In Japan, the Ministry of Land, Infrastructure, Transport and Tourism developed guidelines for the pre-sale inspection of used car parts in 2002. The Japan Automotive Parts Recyclers Association also developed its own updated guideline.

Recommendation 7: Non-AMS should support private sector efforts on transferring advanced technologies for ELV dismantling/recycling to local partners in AMS as well as their initiatives to establish an ELV circularity ecosystem between ASEAN and non-AMS.

Capacity building of knowledge about environmentally friendly ELV processing and practical methods is necessary for ELV recyclers. Training programmes developed and instituted by international stakeholders could help achieve this.

The need for recycled materials is increasing due to the worldwide transition towards a circular economy. The governments of non-AMS could help support ELV dismantlers/recyclers in AMS. As an example, Tsuruoka was motivated to join a JICA project to provide advanced ELV dismantling/recycling technology to a local recycler in the Philippines (i.e. En Tsumugi), seeking the potential of that country as a supplier of metal scraps from ELV. It not only succeeded in the technological transfer but also is helping establish a proper ELV recycling industry ecosystem in the Philippines.

When transferring advanced technologies, it is very important to carry out economic feasibility studies, however. Particularly in the case of archipelagic AMS, logistics costs are key to selecting appropriate technologies.

Recommendation 8: It is desirable for non-AMS to collaborate with AMS to establish some standards for recycled materials to increase the international circularity of ELV-relevant materials through analysis of the cost and capacity of material recycling in each country and to conduct research on battery level testing for reuse and safety.

The need for recycled materials such as metals, non-metals, and plastics is increasing due to the worldwide trend towards the circular economy. Securing the quality of recycled materials domestically as well as establishing international standards within ASEAN will be issues.

Some interviewees in the field surveys pointed out the importance of analysing the cost and capacity of material recycling in each AMS to confirm which AMS and which materials are most efficient to recycle in ASEAN. For example, EV lithium-ion batteries can be recycled through hydrometallurgy, but for hydrometallurgy to be economically viable, many used batteries need to be collected. Thus, AMS should share the role of hydrometallurgical battery recycling and develop appropriate transboundary movement for used EV batteries.

An expert highlighted the importance of establishing not only domestic but an international value chain for EV batteries amongst AMS, as EV batteries contain valuable resources and can contribute to the circular economy. This aligns with the ASEAN Leaders' Declaration, which encourages the harmonisation of regional standards for the EV ecosystem based on international standards to enhance cross-border mobility. An expert also suggested the importance of considering the relationship between ELV recycling and decarbonisation as a long-term issue.

Annex I
Results of Expert Meetings

First Expert Meeting. The first expert meeting was organised online on 25 June 2024. The agenda was as follows: (i) introduction of members, (ii) explanation of survey plan, (iii) explanation of the results of the preliminary literature survey and draft initial inputs, and (iv) discussion.

The survey team explained the results of the preliminary literature survey and draft initial inputs. The experts provided supplementary information about end-of-life vehicle (ELV) recycling in their countries. The experts also proposed information resources for the survey.

Second Expert Meeting. The second expert meeting was organised online on 18 November 2024. The agenda of the meeting was as follows: (i) report on field surveys and country meeting in the Philippines; (ii) presentation from Car Medic, Malaysia on introduction of advanced ELV recycling technologies in ASEAN; (iii) explanation of discussion points (i.e. key findings); and (iv) discussion.

The survey team explained the results from field surveys and the country meeting in the Philippines. The representative from Car Medic introduced its dismantling factory and explained its activities.

After the presentations, the experts discussed the following points:

- How do ASEAN Member States (AMS) address the issue of recycling of EV batteries?
- How do AMS balance informal sector ELV recycling and advanced ELV recycling?
- How can we change the mind-set of citizens?
- What kinds of policies, regulations, and/or standards do AMS require to improve ELV recycling?
- On what issues and how can AMS and non-AMS collaborate?

Third Expert Meeting. The third expert meeting was organised online on 26 February 2025. The agenda of the meeting was as follows: (i) recommendations for AMS and partner countries, and (ii) executive summary and contents of the final report.

The survey team explained the draft recommendations and executive summary. Discussion points were as follows:

- What additional recommendations can be suggested?
- Are the eight recommendations reasonable? Should they be changed and how?
- What level of support should be provided to the informal sector?

The experts provided their opinions mainly on the recommendations and suggested how to revise the recommendations.

Annex II

End-of-life Vehicle Policy and Regulations in Selected ASEAN Member States

1. Indonesia

1.1. Vehicle Registration

The Directorate General of Land Communications oversees the vehicle registration and inspection systems in Indonesia. The basic associated law is Indonesian Law No. 22/2009 on Road Transport and Traffic.

Registration. Under Indonesian Law No. 14 on Traffic and Land Transportation, all vehicles are required to be registered with the government. The Indonesian National Police is responsible for vehicle and driver registration and identification. Compulsory insurance is also required. The *Sistem Administrasi Satu Atap* (SAMSAT, One-stop Integrated Administration System) is used. Registration can be done through a SAMSAT corner (Figure A2.1) or online.

Figure A2.1. SAMSAT Corner for Registration of Vehicles in Indonesia

Source: Samsat Online Polda Metro Jaya, 'With Online Samsat, Paying the Motorbike Tax Is Easier (Ada Samsat Online, Bayar Pajak Motor Semakin Mudah)', https://samsatonlinemetrojaya.wordpress.com/

In addition, prior to the sale and use of a vehicle, manufacturers and importers must register them under vehicle type in an approval system. This includes document application, vehicle testing and inspection, and certification by the Directorate General of Land Transport.

For registration, the *surat tanda nomor kendaraan* (STNK, vehicle registration number), *buku pemilik kendaraan bermotor* (BPKB, vehicle registration book), and *plat nomor* (licence plate) are issued to the vehicle owner. The STNK and BPKB are issued by the local police station.

Registration and updating are then managed by each province. When registering, the following information must be recorded: registration number, registration year, expiration date, owner number, address, manufacturer, vehicle type, mode, year of manufacture, engine number, and type of fuel. It takes approximately 1–2 working days to complete the registration. Registration costs are below.

Table A2.1. Vehicle Registration Costs, Indonesia

(IDR)

Cost	Motorcycle	Car
Administrative cost	80,000	125,000
BPKB production fee	80,000	80,000
STNK printing cost	50,000	50,000
Police number-making fee	30,000	30,000
Name change fee	Taxable principal in SKPD x 2/3	Taxable principal in SKPD x 2/3
Vehicle tax	195,000	195,000
SWDKLLJ (accident insurance)	35,000	143,000

BPKB = *buku pemilik kendaraan bermotor* (vehicle registration book), SKPD = *surat ketetapan pajak daerah* (letter of determination of regional taxes), STNK = *surat tanda nomor kendaraan* (vehicle registration number).

Source: Samsat Online Polda Metro Jaya, 'Change of Name and New STNK (Balik Nama & STNK Baru)', https://samsatonlinemetrojaya.wordpress.com/balik-nama-pembuatan-stnk-baru/

Transfer of vehicle. When changing vehicle ownership, the new owner is required to follow the procedure of obtaining a BPKB and must pay the registration fee.

Re-registration. Vehicle owners are required to renew their car registrations annually. The STNK and *plat nomor* are valid for 5 years.

Deregistration. Vehicle owners need to deregister their cars at police stations. However, in practice, they often sell end-of-life vehicles (ELV) to repair shops instead. In the process of deregistration, owners are required to change the owner details described in the BPKB. The process is done through physical documents only, and the owner is not required to return the *plat nomor.*

Inspection. Commercial and public vehicles must be inspected every 6 months per the Ministry of Transportation. Commercial vehicles need an *Uji Berkala Kendaraan Bermotor* (vehicle inspection certificate) for updating the BPKB. The inspection is conducted at the *Unit Pengujian Kendaraan Bermotor.* Private vehicles are not required to undergo

inspection; *Gabungan Industri Kendaraan Bermotor Indonesia* (Association of Indonesia Automotive Industry) is working to introduce inspections for privately owned vehicles.

Some private companies do offer vehicle inspection services, with the aim of following national standards. Bureau Veritas, a testing, inspection, and certification company from France, has branches in Balikpapan, Batam Medan, Jakarta, and Surabaya. It commenced business in Indonesia in 2001.

The Jakarta City Government enforces regulations for emissions testing (Government Regulation No. 66/2020) for vehicles over 3 years old (Wardhani, 2023). Failed inspections do not have sanctions; therefore, in 2021, only 500,000 out of 21.8 million vehicles were inspected. Penalties are recommended but have been postponed due to the limited number of inspection facilities and the COVID-19 pandemic.

Repair shops and motor vehicle workshops also offer vehicle inspection, which costs IDR40,000. Vehicles that pass the inspection receive certificates, and those with vehicles that do not pass receive technical advice. Results are reported to the Environmental Agency of Jakarta. The Central Jakarta Court requested that the President and Governor of Jakarta enforce periodic emissions inspections for old vehicles in 2021. Motorcycle inspections are also necessary.

Insurance. Insurance is mandatory. A vehicle owner cannot drive a vehicle until it is insured. Third-party insurance is included in the vehicle registration fee through a levy paid to SAMSAT. This is regulated by Law No. 34/1964. The government protects the public from losses caused by road accidents through the implementation of Laws No. 33 and 34, which created PT Jasa Raharja, a government insurance company.

1.2. End-of-life Vehicles

The definition of ELV is not specified in Indonesia. Generally, an ELV is understood to be a vehicle that has reached end of use and cannot be reused. ELV can be classified into two categories: (i) a naturally occurring ELV, which has reached end of use and has been damaged, is un-reusable, or is over 10 years from the date of its production; and (ii) a premature ELV, which is generated due to damage from accidents, fires, or destruction. In addition, some vehicles cannot be reused because they are unfixable, have unpaid taxes, and are missing parts that can no longer be found in the market (Harun et al., 2021).

There are no provisions on vehicle recycling nor a national regulatory system that directly manages ELV in Indonesia. ELV management is subject to monitoring under environmental laws including general environmental legislation from 2009, various ratified environmental conventions, waste management legislation from 2008, local environmental legislation, and provincial environmental legislation. However, ELV recycling is largely managed by the informal sector, and there are no specific policy or regulations for ELV recyclers.

Fluorocarbons. There is no proper facility to collect fluorocarbons in most garages or repair shops. Most refrigerants are released within the dismantling areas. Chlorofluorocarbons (CFC) are generally not recovered, although recovery instruments

have been distributed to some factories.[16]CFC are defined as a B3[17] substance under Law No. 32/2009 and Government Regulation No. 18/1999.

Airbags. The treatment of airbags is not currently regulated. There is no guarantee of the functionality of the used restraint component with inflator contents (i.e. airbags and seatbelt pretensioners). Even if the electrical indicator shows normal operation (i.e. no airbag light 'on' in the instrument cluster), it may only show the normal resistance value of the component.

Automobile shredder residue (ASR). There are no official vehicle shredders in Indonesia. Metallic component recycling is done by manual cutting. The shredding process is not developed due to the limited number of ELV.

Batteries. Waste lead batteries are designated as B3 waste. According to Government Regulation No. 19/1994:

> [t]he process of changing the characteristics and composition of the B3 waste [must be] performed so that the waste becomes non-hazardous and/or non-toxic. The process can be performed by using appropriate technology, such as stabilization and solidification, incineration, landfill and neutralization. If such technology cannot be applied, the best available technology to process the waste, such as ion exchange and membrane cells, shall be applied. Recycling means the processing by recovery and reuse of waste.

In addition, Government Regulation No. 18/1999, which repealed Government Regulation No. 19/1994, states that:

> the utilization of B3 waste is an activity of recovery and/or reuse and/or recycle with a view to changing B3 waste into a product which may be used and must also be sage to the environment and human health.

B3 waste must be processed by B3 waste management companies that have obtained permission from the Ministry of Environment and Forestry. However, in practice, waste management companies without permission collect lead batteries and implement improper treatment.

Tires. The informal sector recycles or reuses used tires. There is no policy nor strategy involved (JICA, 2016).

Waste oil. Government Regulation No. 22/2021 regulates reusing waste oil as alternative fuel. It mentions that B3 waste can be utilised as a raw material substitute, energy resource substitute, or raw material. To use the waste, businesses must obtain technical approval. Moreover, the use of hazardous waste as an alternative energy source – in particular the use of oil sludge, oil sloop, and waste oil – can occur in the cement industry. However, hazardous waste should meet the standards noted in Table A2.2.

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[16] The Narogong factory of PT Holcim Indonesia is the first factory of cement kilns, which directly destroy CFC.

[17] B3 is a substance or material that may, either directly or indirectly, contaminate and or damage the living environment and/or may harm the living environment, health, survival of humans, and other living creatures.

Table A2.2. Standards for Alternative Use of Hazardous Waste in the Cement Industry, Indonesia

Hazardous Component	Standard
Arsenic	≦ 5.0 ppm
Cadmium	≦ 2.0 ppm
Chromium	≦ 1,500.0 ppm
Lead	≦ 100.0 ppm
Mercury	≦ 1.2 ppm
Polychlorinated biphenyls	≦ 2.0 ppm
Total TOX amount (fluorine and chlorine)	≦ 2%
Calorie	≦ 2,500 kcal/kg, dried weight or 1,000 kcal/kg, wet weight

Kcal = kilocalorie, kg = kilogram, ppm = parts per million.
Source: JICA (2016).

1.3. Recycling

The Ministry of Environment and Forestry is promoting a circular economy in Indonesia. Thus, the General Directorate for Strategic Planning 2020–2024 was established to (i) implement the circular economy to improve community well-being, (ii) implement a 'cradle-to-cradle' scenario by increasing the recovery of hazardous waste, and (iii) promote the substitution of hazardous substances with environmentally friendly materials.

The government has begun to promote plastic recycling and reuse as part of its efforts to achieve a circular economy. The Joint Decree of Minister of Trade No. 482/2020, Minister of Environment and Forestry No. S.235/MENLHK/PSLB3/PLB.3/ 5/2020, Minister of Industry No. 715/2020, and Police Chief No. KB/1/V/2020 was enacted to regulate non-hazardous and toxic waste importation of industrial raw materials. It mandates that the recycling industry prepare a roadmap that prioritises accelerating the availability of domestic industrial raw materials such as plastic.

The government also aims to achieve a circular economy by promoting producer responsibility, waste banks, and the recycling industry. To promote producer responsibility, the concept of extended producer responsibility (EPR) has been introduced. Ministry of Environment and Forestry Regulation No. 75/2019 was enacted to encourage producers to develop EPR roadmaps (JETRO, 2024b). Its targets are manufacturers (i.e. of food and beverages, consumer goods, and cosmetics), retailers (i.e. modern stores, shopping malls, and markets), and the food and beverage sector (i.e. restaurants, cafés, hotels, and catering services). Producers should aim to reduce 30% of waste at production and to treat 70% of waste by 2029. The regulation also aims to promote the collection of used packages or post-consumer recycled resin packages for reuse and recycling by their

producers to reduce plastic and paper waste.[18]

In July 2024, the Ministry of Environment and Forestry announced the Zero Waste Zero Emission 2050 campaign to achieve net-zero emissions by 2060. It aims to create no new landfills by 2030, have no open burning by 2030, and have no landfills by 2050. It is expected that Indonesian waste regulations will also be further developed.

1.4. Waste Management

In general, industrial and hazardous waste related to ELV are regulated by Law No. 32/2009 (Japan Industrial Waste Technology Center, 2016). There are also many regulations and legislation in Indonesia that are related to or directly govern waste management and protection (Kojima, 2018), which can be classified into five categories.

General environmental legislation. This encompasses legislation accompanied by implementing regulations governing environmental management in general and covers all sectors, such as Law No. 23/1997.

Sectoral environmental legislation. This is legislation accompanied by implementing regulations governing certain sectors closely related to environmental management, such as (i) Law No. 32/2009, which requires preparation for strategic environmental studies, implementing the principles of sustainable environmental protection and management and prioritising a preventive approach; (ii) Law No. 18/2008, which notes that waste is a resource that has economic value and can be reused to improve community welfare; (iii) Government Regulation No. 85/1999; (iv) Government Regulation No. 18/2009; (v) Government Regulation No. 74/2001; (vi) Government Regulation No. 101/2014, which regulates the management of hazardous and toxic waste including production, transport, storage, processing, and disposal; (vi) Government Regulation of the Minister of Public Works No. 21/PRT/M/2006; (vii) National Standards of Indonesia 3242 Year 2008; (viii) Government Regulation No. 27/2020, which mandates systematic and sustainable management of e-waste including producers' obligation to reduce and be responsible for e-waste generation; (ix) Ministry of Environment and Forestry Regulation No. 14/2021, which accelerates domestic industrial recycling of raw materials as a substitute for imported raw materials, especially for plastic and paper; (x) Government Regulation No. 22/2021, which aims to control environmental damage and mandates that the government provide incentives to the private sector that implement environmental protection and management as well as undertake regular supervision and monitoring to assess the effectiveness of efforts; and (xi) Ministry of Environment and Forestry Regulation No.12/2021, which defines emissions quality standards for the private sector and/or recycling activities for used lithium batteries to avoid air pollution.

Ratified environmental conventions. The Basel Convention is underscored by Presidential Decree No. 61/1993. Presidential Decree No. 47/2005 was also passed to prohibit exporting hazardous waste from developed countries to developing countries without prior approval. The Convention on Climate Change is also endorsed through various provincial environmental legislation and local environmental legislation.

[18] According to the Japan External Trade Organization, however, only more developed companies are following the regulation because it is not yet mandatory.

Regulations for solid waste management. Various ministries have established the following regulations for solid waste management in local government: Ministry of Public Works Regulation No. 3/2013; Ministry of Environment and Forestry Regulations No. P.70/2016, No. P.59/2016, No. P.10/2018, No. P.76/2019, No. P.26/2020, and No. 6/2022; Ministry of Home Affairs Regulations No. 79/2018 and No. 7/2021; and Ministry of Finance Regulation No. 26/2021.

Hazardous waste management. The Ministry of Environment and Forestry oversees regulations related to hazardous waste management. Law No. 32/2009 and Regulation No. 18/1999 defines B3 waste. Article 59, paragraphs 1–6 of Law No. 32/2009 stipulate: (i) anyone who produces hazardous waste must carry out hazardous waste management; (ii) expired hazardous substances must be managed in accordance with hazardous waste management regulations; (iii) if an entity is unable to manage its own hazardous waste, it can be managed by someone else; (iv) hazardous waste management activities must be authorised by the minister, governor, or regent/mayor in accordance with authorities; (v) the minister, governor, or regent/mayor must specify in a permit the environmental requirements to be met and the responsibilities that the hazardous waste manager must fulfil; and (vi) the decision to grant a permit/licence for hazardous waste handling must be made public. Article 102 notes that anyone treating B3 waste without a permit is subject to imprisonment of 1–3 years and a fine of IDR1 billion–IDR3 billion. Article 103 states that anyone producing B3 waste and not conducting the treatment as referred to in Article 59 is subject to imprisonment of 1–3 years and a fine of IDR1 billion–IDR3 billion.

Government Regulation No. 27/2020 applies to waste such as waste containing hazardous substances, waste resulting from disasters, construction waste, waste that cannot be processed technologically, and waste that is not produced regularly. Examples of specific waste are that used for product packaging, electronic waste, and expired hazardous substance waste. Electronic waste also includes used batteries. Regulation No. 27/2020 states that electronic and/or electrical goods from households that are no longer used due to their nature, concentration, and/or volume require special management. The Ministry of Environment and Forestry expects the potential economic impact of e-waste recycling to be around USD1.8 billion in 2020 (MOEF, 2024)

Government Regulation No. 22/2021 is recognised as an important regulation for achieving a circular economy in Indonesia. The Ministry of Environment and Forestry is promoting the recovery of hazardous waste and management of non-hazardous waste. Based on this management concept, raw materials from hazardous waste should be used to replace natural materials, replace raw materials in the production of products, or be used for energy. Hazardous waste is mainly used as a raw material for ingots and as a substitute for cement raw materials.

According to an expert for this survey, the Enhancing Readiness for the Transition to Electric Vehicles in Indonesia Project – which started in 2023 and is funded by the Global Environment Facility – has created a draft concept of e-waste treatment and specific treatment of batteries to the Ministry of Environment and Forestry; however, there has been no update as of November 2024. The project proposes a strategic policy and solution for battery disposal and waste battery management, and a strategic environmental and social assessment was conducted. It suggests utilising used batteries from electric vehicles (EV) with less than a 20% degradation level in energy storage systems.

1.5. Licences for Recyclers

The informal sector is the main actor in recycling activities in Indonesia. Policies and regulations on licensing of recyclers were not found. However, there are licences for the management of hazardous waste relevant to ELV. Law No. 32/2009 notes that companies or organisations that import, produce, transport, distribute, collect, store, use, or process B3 waste are responsible for waste management. Companies must register in an electronic registration system according to Ministerial Decree No. 2/2010 at the Indonesia National Single Window at the Ministry of Environment and Forestry. A B3 waste importer/exporter is required to submit a certificate of establishment, business permit, business registration number, taxpayer registration number, importer number, material safety data sheet, certificate of analysis, and a photograph of its storage warehouse through the window for registration.

1.6. Recycling Facilities

Regulation of the Ministry of Public Works No. 3/2013 defines the facilities and infrastructure necessary to deal with waste. The objectives of the regulation are to improve the scope of waste-handling services; improve the level of community health and quality of the environment; protect water, land, and air from pollution and mitigate climate change; and formulate waste as a resource.

Based on the regulation, domestic waste management includes sorting, collection, transport, processing, and final waste treatment. These processes are carried out at temporary waste disposal sites, 3R[19] waste treatment facilities, and final processing sites (Ministry of Public Works, 2013). Temporary waste disposal sites are places where waste is collected before it is recycled, processed, and/or integrated into a waste treatment facility. 3R waste treatment facilities are places where collection, sorting, reuse, and recycling processes occur. Final processing sites are places where household and residual waste is processed.

Activities in 3R waste treatment facilities include waste accommodation, sorting waste, processing organic waste, recycling non-organic waste, processing household-specific waste and hazardous waste (i.e. B3) according to the applicable provisions, collecting residual waste, and placing it into a container for transport to the final processing site.

Based on the regulation, 3R waste treatment facilities must be larger than 200 square metres, have facilities that enable sorting of at least five types of waste, have sorting space to make organic compost and/or biogas-producing units, be able to accommodate remnants of the waste processing, be located as close as possible to the service area within a radius not exceeding 1 kilometre, be easily accessible, not cause environmental pollution, and have a schedule for collection and transport.

The provision of waste-processing facilities should be made in phases of technical planning, construction, operation and maintenance, and monitoring and evaluation. Construction activity must be in accordance with *rencana mutu kontrak/kegiatan* (contract quality plans) and *rencana keselamatan dan kesehatan kerja kontrak/kegiatan* (contract occupational safety and health plans) prepared by the operator or service provider for the

[19] Reduce, reuse, recycle.

construction.

2. Malaysia

2.1. Vehicle Registration

Registration. In Malaysia, the Road Transport Department oversees new vehicle registration, transfer of registration, re-registration, and deregistration of vehicles under the Road Transport Act 1987 and Motor Vehicle (Registration and Licensing) Rules 1959 (Government of Malaysia, 2013). Applications for vehicle registration should be submitted in a prescribed form to the director of each registration area or each division of the Road Transport Department.

All vehicles should be registered in Malaysia. The owner's registered address and registration number are connected. Users are required to pay MYR200 as an ownership registration fee for vehicles less than 1,500 cubic centimetres and MYR350 for vehicles more than 1,500 cubic centimetres. Vehicle owners are required to pay taxes for registration, road, and insurance (Table A2.3).

Table A2.3. Taxes for Owning Vehicles, Malaysia

Fee		Detail
1	Registration fee	Paid on registration and re-registration
2	Road tax	Paid upon purchasing a car
3	Compulsory insurance	Certification of paying issuance is required for renewal of registration.

Source: Kojima (2018).

Transfer of ownership. Within 7 days of a change in vehicle ownership, the owner of the vehicle must notify the director of the registration area, and the certificate of registration should be sent to the new owner by the original owner. The new owner must, within 7 days of the change of ownership, send a declaration in the prescribed form to the director with the certificate of registration.

Re-registration. In case of re-registration, owners are required to pay MYR30 for re-registration at a post office. The registration must be renewed annually.

Deregistration. Deregistration is done at the Road Transport Department counter at a local government office; it costs about MYR500 to deregister a vehicle. Local governments can impose a penalty on ELV owners who do not take any action 6 weeks before their vehicle becomes an ELV. The ELV owner needs to pay a confirmation fee of MYR80 then move to the deregistration process. Previously, vehicle owners had to bear the entire cost of deregistering a vehicle – from the initial notification to the towing of the vehicle to the storage facility – which cost MYR1,500.

In 2024, the Ministry of Transport launched the e-Dereg system. It is a door-to-door deregistration and free towing service for ELV owners. The programme gives an authorised automotive treatment facility (AATF) a licence to deregister ELV before they

are scrapped to ensure that the scrapped vehicles no longer exist in the system and on the road. It allows vehicle owners to deregister their vehicles through Car Medic, the AATF, by calling, sending WhatsApp messages, or emailing Car Medic; they must send four photos of the vehicle, information about its location, and a photo of the registration card. Owners are also required to complete a scrappage application form as proof of consent. Vehicle owners make an appointment with Car Medic, and technicians then visit their home to inspect the vehicle. After the inspection and deregistration process, Car Medic will tow the vehicle from the owner's home to the Car Medic facility. This programme is also designed to assist older persons and those who have difficulty moving their vehicles.

Inspection. Per the Road Traffic Act, only commercial vehicles are subject to annual inspections. This is carried out by PUSPAKOM, which is the only authorised private company. It has 83 inspection centres throughout the country, carrying out more than 3 million inspections per year. The company is also responsible for the inspection of imported vehicles (both new and used) on behalf of the Royal Malaysian Customs Department. In addition, spot checks can be carried out on the roads. A penalty is imposed on a commercial vehicle if it does not have a sticker indicating that it has been inspected.

The *National Automotive Policy 2009* made inspections mandatory as a condition for the renewal of road taxes for all vehicles aged 15 years or more. This initiative was expected to serve as a first step towards the full implementation of an ELV policy. Later, the *National Automotive Policy 2014* (Government of Malaysia, 2014) introduced the Voluntary Vehicle Inspection Program and the Mandatory Vehicle Inspection Program (Jamaluddin et al., 2022). These initiatives were continued until the *National Automotive Policy 2020* (MITI, 2020). According to the Malaysia Automotive Robotics and IoT Institute (MARii), it is very likely that an inspection system for private vehicles will soon be introduced in Malaysia.

In March 2024, the Road Transport Department published new guidelines for vehicle inspection centres, which serve as a reference for all parties regarding qualification/service requirements, procedures, rules, standards, and regulatory procedures for granting licences and operating motor vehicle inspection. The guidelines are regulated under the Road Transport Act 1987 [Act 333]. The department also has the right to impose other conditions on licences that are not included in its guidelines. Licences are valid for a maximum of 10 years but can be renewed.

MARii pointed out during the survey that periodic inspections of private vehicles will ensure vehicle roadworthiness, safety, standards and regulations. The inspections may cover various safety aspects, including brakes, tires, lights, steering, and suspension. The intervals for these inspections can be determined based on factors such as vehicle age, usage, and local safety regulations. MARii recommends conducting an initial inspection after 3 years from a vehicle's first registration. Afterward, inspection should be conducted every 2 years for most vehicles. However, for commercial vehicles (e.g. lorries, trucks, trailers, taxis, rental cars, or vehicles used for commercial purposes), motorcycles, or vehicles aged more than 12 years, an inspection should be required annually. It is also proposed that for first phase of implementation, vehicle inspection be conducted for all vehicles aged more than 12 years. The proposed periodical inspection interval is as follows:

Table A2.4. Recommendations for Vehicle Inspection, Malaysia

No.	Activities	Year 1–3	Year 4–7	Year 8–10 and Beyond
1	Mandatory inspection for all vehicles aged more than 10 years			
2	Insurance premium incentive (i.e. reduction) for inspected vehicle (continuous)			
3	Mandatory vehicle inspections: • Passenger cars. Initial inspection after 3 years from vehicle's first registration; inspections then conducted every 2 years • Motorcycles. Initial inspection after 3 years from vehicle's first registration; inspections then conducted yearly • Commercial vehicles. Initial inspection after 3 years from vehicle's first registration; then inspections conducted yearly			

Source: MARii (2024).

Insurance. Car insurance is compulsory in Malaysia; it is a criminal offence to drive without insurance. There are three main types of insurance available. The most basic is known as Act Only Insurance. It covers only death or injury in the event of an accident. The next level is third-party insurance, which also covers accidents to third-party vehicles, fire and theft, and some minor injuries. The highest level of insurance is full comprehensive insurance, which covers all fire, theft, and accidental damage regardless of liability and often has clauses such as legal cover. Car insurance can be paid in a lump sum or on a monthly automated basis via direct debit.

2.2. End-of-life Vehicles

ELV are defined in Malaysian Standard (MS) 2697:2018 as a type of motor vehicle that is intended to be or is required to be discarded, including metal sent for recycling or reuse. Although there is no specific law regarding ELV management, there are initiatives and regulations regarding ELV management.

The Ministry of Investment, Trade and Industry oversees the overall policy related to vehicles such as national automotive policies, and the Ministry of Science, Technology and Innovation oversees proper disposal of ELV per the Environmental Act. The government has also developed national automotive policies since 2006 (MITI, 2009). MARii has supported the government in formulating the national automotive policies for 2014 and 2020.

The *National Automotive Policy 2020* promotes the adoption of new and more environmentally friendly elements of technologies that will address the issue of pollution and emphasise the safety of vehicles and consumers (MITI, 2020). The policy aims to reduce the rate of road accidents and to protect consumer rights related to spare parts and services, including vehicle maintenance and the automotive recall process. Further, it aims to transform the automotive industry, moving towards a connected mobility ecosystem by 2030.

To complement the execution of the *National Automotive Policy 2020*, the government has also established roadmaps and blueprints for seven areas. They outline the initiatives and strategies on the automotive and mobility value chain, technology, talent, robotics, internet of things, and aftermarket, under the supervision of Ministry of Investment, Trade and Industry and MARii. The Ministry of Investment, Trade and Industry and MARii will coordinate, implement, and monitor the programmes. These roadmaps will serve as the guidelines to achieve the transformation objective of the local automotive industry and include the *National Roadmap for Automotive and Mobility Value Chain, National Roadmap for Automotive and Mobility Technology, National Roadmap for Automotive and Mobility Talent, National Roadmap for the Automotive Aftermarket, National Blueprint for Automotive Mobility as a Service, National Blueprint for Automotive Robotics,* and *National Blueprint for Automotive Internet of Things.*

The *National Roadmap of Automotive Aftermarket* outlines detailed criteria through improvements of remanufacturing, standards, and best practices that can be adopted by domestic automotive stakeholders to make Malaysia an automotive remanufacturing hub in ASEAN. It also provides guidelines for optimising the quality of automotive recycling and reuse of components such through gig data analysis that could potentially increase revenue or enhance the effectiveness and efficiency of after-sales operations through customer and vehicle data analysis, maintenance, and optimisation of logistics planning.

The government set a goal to achieve 70% material recyclability and recoverability by 2030. Towards this goal, the *National Roadmap of Automotive Aftermarket* will support the industry in developing significant skills and competencies, encouraging the application of high technology and development of standards, and providing necessary facilities for the automotive recycling industry. The government aims to transform the recycling industry into a regulated industry that is environmentally and consumer friendly through green initiatives of automotive recycling. It is also setting targets under the *National Roadmap of Automotive Aftermarket* to develop AATF policy, establish standards, and create testing and certifications to establish 21 AATF and 206 vehicle inspection centres by 2030.

MARii is supporting the government to achieve these targets in service and maintenance, remanufacturing, and AATF. It has been developing integrated standards, an energy-efficient vehicle repair time management system, and multiple kinds of workshop centres.

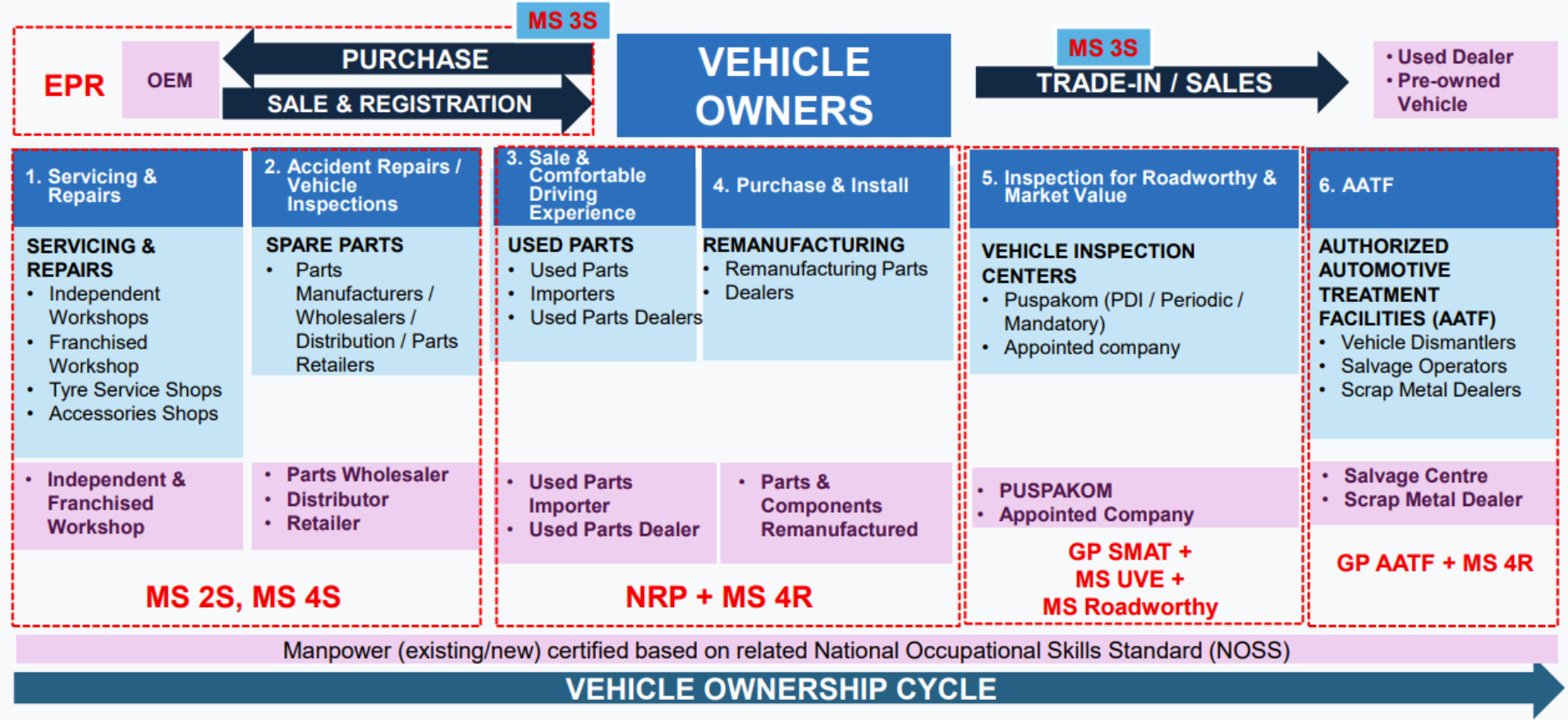
The government is also promoting used parts standards through the National Standards Committee, which is under the Department of Standards. This was established to oversee national and international standardisation activities. MARii is involved in developing standards as a representative of the transport sector. MS that are related include (i) 2696:2018, which prescribes industry best practices for after-market service provider activities including regarding requirements of 4M (i.e. man, method, machine, and material); (ii) 2697:2018, which specifies requirements for 4R (i.e. reduce, reuse, recycle,

and remanufacture) activities of vehicle parts and components; (iii) 2725:2021, which prescribes vehicle sales responsibility and management system requirements of 4M; (iv) 2726:2022, which details prescribes requirements of 4S (i.e. service, spare parts, sales, and smash repair) workshops and parts shop activities, and responsibility of operators regarding 4M, facilities, training, and competency of staff; (v) 2728:2023, which prescribes requirements for evaluations for used vehicle rating systems in the market to provide fair and accurate inspections; and (vi) 2729:2023, which prescribes requirements to conduct accurate vehicle inspections for safer vehicle use.

MS 2697:2018 was developed as a guideline for developing process control systems for 4R of ELV parts or components. This standard ensures that AATF follow proper process and disposal of ELV. MS 2726:2024, 2728:2023, and 2729:2023 are the standards to promote ELV supply to AATF. Guidelines for EV battery recycling and remanufacturing are under development and will be formulated based on MS 2697:2018.

Servicing and repair and accident repairs/vehicle inspection should meet MS 2696:2018 and 2726:2024. Sales, a comfortable driving experience, purchase, and installation should meet the *National Remanufacturing Policy* and MS 2697:2018. Inspections for roadworthiness and market value should meet *Garis Panduan Sistem Maklumat Automotif Terpakai* (Guideline for Used Automotive Information System), MS 2728:2023 (MS UVE), and MS 2729:2023 (MS Roadworthy). The process of AATF should follow guidelines issued by the Department of Environment and MS 2697:2018 (Figure A2.2).

Figure A2.2. Automotive Eco-system in Malaysia



EPR = extended producer responsibility; GP AATF = Guideline for Authorised Automotive Treatment Facilities; GP SMAT = *Garis Panduan Sistem Maklumat Automotif Terpakai* (Guideline for Used Automotive Information System); MS 2S - MS 2696:2018 = motor vehicle aftermarket - service and spare parts (2S); MS 3S - MS 2725: 2021 motor vehicle – sales – requirements; MS 4S - MS 2726: 2024 motor vehicle aftermarket - smash repair – requirement; MS 4R - MS 2697:2018: motor vehicle aftermarket - repair, reuse, recycle and remanufacture (4R) for parts and components – code of practice; MS UVE - MS 2728:2023: used motor vehicle classification - requirements for evaluation; NRP = *National Remanufacturing Policy*; OEM = original equipment manufacturer.
Source: MARii.

In Malaysia, the Malaysia Automotive Recyclers Association (MAARA) works to promote automotive recycling. It aims to be the prime national, specialised, non-profit association dedicated to the members of the Malaysian auto parts recycling industry (Japan Automotive Recyclers Association, 2019). It works to be environmentally responsible, proactive, and an essential part of the community; promote professionalism in the automotive parts recycling industry; improve the recycling rate as well as environmental protection; implement the 3R concept; and be the recognised authority for the automotive parts recycling industry and acknowledged as the contact point for automotive parts recyclers, automotive trade industry bodies, regulatory authorities, and the general public.

MAARA is involved in research and development related to the automotive recycling industry in Malaysia, including ELV management, EV, sustainable recycling practices, and the circular economy. A research paper was published by Universiti Utara Malaysia in collaboration with MAARA on the possible effects of the national automotive policy on prohibiting the importation of used automotive parts and components. It pointed out the necessity of providing enough time for automotive used parts and components traders to build their capacity in the automotive recycling industry, which was estimated to affect more than 5,000 enterprises and 200,000 workers. It recommended that the government introduce capacity building and a cluster approach to increase the exportation of new and recycled automotive components and parts competitively in the global market. The research also highlighted the need for a robust ELV management framework in Malaysia to ensure proper disposal and recycling of ELV. The result of research led the government to allow the importation of used ELV parts.

Regarding specific components in the Malaysian ELV recycling system:

Airbags. Currently, proper treatment of airbags is not regulated. However, under the *National Automotive Policy 2020,* the airbag is designated as an automotive component, which is an object of reuse.

Automobile shredder residue. Shredding and sorting plants are a new addition to the proposed Malaysian ELV recycling system. Currently, ASR is sent to ASR incinerators. Incineration serves two purposes: to extract the energy and to reduce ASR weight. The by-product is a molten slag, which can be used as bricks or additional ingredients in concrete, while the rest, if any, is sent to landfills.

Generators of ASR are not required to have licences as prescribed premises for waste management from the Department of Environment. Only receivers of ASR (i.e. treatment or disposal and transporter providers) must have licences as stipulated under Section 18 of the Environmental Quality Act.

If ASR contains heavy metals or is contaminated with coolant, oil, or grease, it is considered scheduled waste under the Environmental Quality (Scheduled Waste) Regulations 2005 and is subject to regulation (MITI, 2020).

Batteries. Generally, used batteries are collected and sold to recycling companies such as Metal Reclamation Bhd. Batteries are categorised as scheduled waste. According to the Environmental Quality (Scheduled Waste) Regulations 1989/2005, every waste generator of batteries must ensure that the scheduled waste generated is properly stored; treated on site; recovered on site for materials or products; or delivered to and received at prescribed premises for treatment, disposal, or recovery of materials or products. Also, the recovery of materials or products from waste batteries must occur at

prescribed premises or at on-site recovery facilities. Residuals from recovery of materials or products from scheduled waste must be treated or disposed at prescribed premises.

Fluorocarbons. CFC for air-conditioners are collected by recovery equipment and stored in gas bombs. However, CFC are released in the air when confirming gas leaks. Hydrochlorofluorocarbons are not currently a target of regulation. However, the Department of Environment is considering including them in the target and is planning to elaborate a control plan.

Others. All ELV are sent to dismantling facilities, which are registered by MAARA. Vehicles undergo a de-pollution stage where all fluids are drained and stored for the respective recyclers. Batteries, mercury, and other pollutant agents are also removed at this stage. Usable parts are harvested and enter the used spare parts market. Unusable or heavily damaged parts will be sorted according to their respective material and then sold to recyclers. Parts that cannot be sold or recycled are sent for disposal.

2.3. Recycling

There are three main policy and regulations on recycling in Malaysia. The Malaysia Solid Waste and Public Cleansing Management Act 2007 states that any solid waste must be disposed of, burned, deposited, or decomposed. The *National Strategic Plan for Solid Waste Management 2019–2030* was developed to lower waste generation, boost recycling rates, and enhance waste management facilities. Finally, the EPR Policy mandates that importers and manufacturers oversee the entire product life cycle, including waste management.

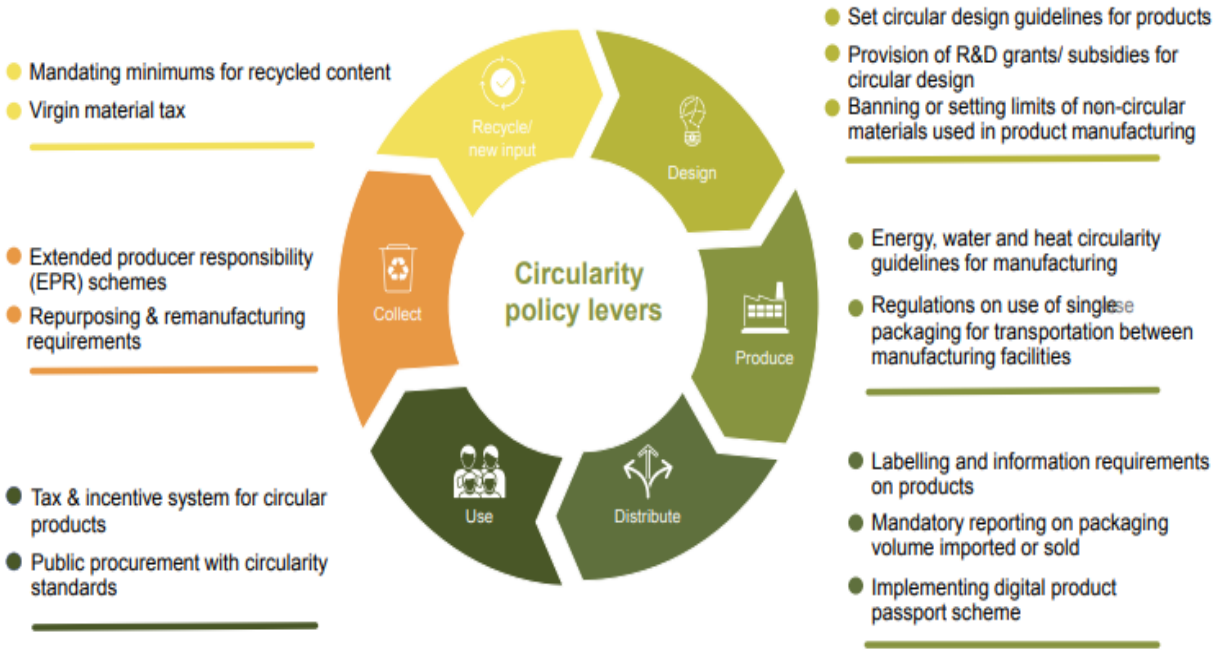
The concept of recycling is incorporated into the *Twelfth Malaysia Plan 2021–2025* as well, which aims to achieve sustainable development (MOE, 2021). It notes that mandatory vehicle inspection plays a significant role in supporting the ELV ecosystem implementation not only in terms of environmental sustainability for the circular economy but also to promote the ELV industry in Malaysia. In the past, the ELV industry had to rely on abandoned vehicles, which did not support the recovery of reusable components due to the severity of damage of the reusable components.

The Ministry of Investment, Trade and Industry initiated *Circular Economy Policy Framework for the Manufacturing Sector* in 2024 (MITI, 2024). The framework sets out four key themes based on material flow: circular input, efficient process, sustainable output, and socio-economic impact. Each theme has targets to achieve. The circular material use rate is to rise to 1.2% from 0.3%. Resource productivity will grow from USD539 per tonne to USD700 per tonne. Regarding sustainable output, industrial waste generated will fall from 165 tonnes per USD1,000 of manufacturing gross domestic product (GDP) to 135 tonnes per USD1,000 of manufacturing GDP. Finally, towards a socio-economic impact, the gross value-added will increase from circular economy sectors from MYR6.3 billion to MYR20.0 billion, and the number of jobs in circular economy sectors will expand from 90,000 to 200,000.

Towards these goals, the Ministry of Investment, Trade and Industry conducted a benchmarking exercise by analysing policy levers across six segments of the value chain for the manufacturing sector: design, production, distribution, use, collection, and recycling/new input. It clarified policy considerations and levers for each segment as

shown in Figure A2.3. Stakeholders in the circular economy ecosystem are expected to have discussions to consider and establish associated policies.

Figure A2.3. Examples of Circularity Policies across the Value Chain, Malaysia



Source: MITI (2024).

The framework identified 14 initiatives and enablers to achieve the targets and to promote development of the circular economy ecosystem in Malaysia. Amongst the 14 initiatives, the following are related to ELV management.

Initiative A2 (circular input): Implement minimum circular content requirements. The initiative aims to establish gradual increases in minimum percentage requirements for circular/recycled materials. It is expected that the usage of circular materials will increase through greater adoption of circular content into products, reducing the volume of landfills, and increase resource productivity by reducing reliance on virgin raw materials. Key activities are to define eligible types of circular content (e.g. recycled, reused, or remanufactured content) as well as the specific threshold for circular content in products such as packaging, electrical goods and electronics, and consumer goods. To support stakeholders, it is necessary for the government to implement transition programmes for companies as well as grants, subsidies, or tax incentives to encourage the participation of small and medium-sized enterprises (SMEs). Key focus product groups include batteries for the automotive sectors. The government also aims to set up third-party certification schemes for the verification process and to create new business opportunities led by the Ministry of Investment, Trade and Industry.

Initiative C2 (sustainable output): Develop a digital waste-to-value marketplace. This initiative aims to establish an effective digital waste-to-value marketplace by matching materials and manufacturers. It will incorporate a directory of waste or by-products itemised by waste categories (and potentially waste codes) and harmonised across sectors based on guidelines to identify appropriate manufacturers. It will contribute to

increasing the use rate of circular materials by enabling companies to better identify and to integrate recycling rates into their products. This initiative can be piloted between sectors with high synergies such as the automotive sector and metal sector. This initiative will be led by the Ministry of Investment, Trade and Industry and the Waste Management Association of Malaysia.

Initiative C3 (sustainable output): Drive EPR adoption amongst manufacturers. This initiative focusses on the transition from the voluntary EPR scheme to a mandatory one over 3–5 years in key sectors. The Department of Environment is exploring EPR for select consumer electronics categories. It set a timeline for AATF dismantling, EPR standards, and manufacturing sectors' responsibility for recycling materials. To implement EPR, upskilling and provision of financial assistance (e.g. tax exemptions) to SMEs will be provided for pilot studies. The sector-led pilot programmes will also allow for early identification of issues such as those relating to infrastructure, finance, and compliance. This initiative will help ensure sufficient use of recycled inputs, increase the availability of recyclable material, and complement other initiatives such as Initiative A2 to ensure minimum circular content in products. This initiative will be led by the Ministry of Investment, Trade and Industry; Ministry of Housing and Local Development; and Department of Environment.

In addition, circular economy stakeholders for the manufacturing sector should be aware of a supply chain risk. There is a trend to reduce the use of virgin materials for energy and cost savings. The EV manufacturing segment may be affected by the trend since nickel and cobalt are in demand for manufacturing EV, although their scarcity is also a prominent issue.

2.4. Waste Management

The Environmental Quality Act 1974 is the basic law for environmental issues. Waste management is also mentioned in this law. The law was amended in 1985, 1996, 2000, and 2001.

Under the Environmental Quality Act, various orders and regulations regulate recycling/waste management facilities' licences and how to treat waste. The Environmental Quality (Licensing) Regulation 1977 regulates licensing based on the Environmental Quality Act. Environmental Quality (Prescribed Premises) Scheduled Waste Treatment and Disposal Facilities Regulation 1989 regulates the procedure for scheduled waste by facilities. Environmental Quality (Scheduled Waste) Regulation 2005 is the comprehensive regulation for scheduled waste, which defines the list of scheduled waste, licensing, and responsibility of dischargers and certified operators. Finally, the Environmental Quality (Refrigerant Management) Regulation 1999 and (Amendment) Regulation 2004 codifies the treatment of and prohibited matters regarding environmentally harmful substances for cooling.

In 2018, rules related to the management of idle vehicles or abandoned vehicles were created. Based on this policy, collection of material waste includes vehicle components that can be reused or recycled, in line with the national goals for environmental sustainability. Abandoned or discarded vehicles contaminated with scheduled waste and whose registration has been cancelled are categorised under Code BT SW 422, a mix of scheduled waste and non-scheduled waste (Schedule 1, Environmental Quality

[Scheduled Waste] Regulations 2005).

Table A2.5. Scheduled Waste from Abandoned Vehicle/parts, Malaysia

Item	Photo	Code	Details
Vehicles that have been deregistered		SW 422	Idle or abandoned vehicles tainted with scheduled waste and with cancelled registrations are categorised under BT Code SW 422 (i.e. scheduled waste mixture and not scheduled waste per Table 1, Regulations Environmental Quality (Scheduled Waste) 2005)
Vehicle batteries (lead acid)		SW 102	
Vehicle batteries (lithium-ion and nickel metal hydrate)		SW 103	
Electronic waste		SW 110	
Catalytic converters		SW 202	Idle or abandoned vehicles tainted with scheduled waste and with cancelled registrations are categorised under BT Code SW 422 (i.e. scheduled waste mixture and not scheduled waste per Table 1, Regulations Environmental Quality (Scheduled Waste) 2005)
Used engine oil, hydraulic oil, brake oil		SW 305 SW 306	
Used transmission oil		SW 306	
Used gearbox oil		SW 306	Idle or abandoned vehicles tainted with scheduled waste and with cancelled registrations are categorised under BT Code SW 422 (i.e. scheduled waste mixture and not scheduled waste per Table 1, Regulations Environmental Quality (Scheduled Waste) 2005)
Engine coolant		SW 327	
Shock absorber (oil)		SW 422	

Item	Photo	Code	Details
Oil filters		SW 410	
Airbag detonators (*sodium azide*)		SW 422	Idle or abandoned vehicles tainted with scheduled waste and with cancelled registrations are categorised under BT Code SW 422 (i.e. scheduled waste mixture and not scheduled waste per Table 1, Regulations Environmental Quality (Scheduled Waste) 2005)
Air conditioner liquid or gas			Main cause of the depletion of the ozone layer global warming; subject to the Environmental Quality Order (Prohibition on the Use of Chlorofluorocarbons and Other Gases as Propellants and Agents Developer) 1993

Source: eSWIS, First Schedule, https://eswis.doe.gov.my/wasteList.aspx.

2.5. Licences for Recyclers

The government is aiming to build 21 AATF by 2030 under the *National Roadmap of Automotive Aftermarket*. The *National Automotive Policy 2020* aims to achieve a 70% ELV recyclability rate through research and development towards commercialisation of AATF services. During the site visit by the study team, automotive sector stakeholders mentioned that AATF would be the only certified institutions that could implement ELV processing in near future.

The Department of Environment published AATF guidelines in 2021 and updated them in 2022. The AATF guidelines define the procedures for operating abandoned vehicles under the provisions of Sections 11 and 18 (1), Environmental Quality Act 1974. AATF are certified under MS 2697:2018; they must acquire licences from the Department of Environment to handle scheduled waste as well. Those institutions without certificates are not allowed to be part of ELV dismantling and recycling flows. AATF include dismantlers, used parts dealers, and scrappers. MARii mentioned to the study team that it is expected that laws and regulations regarding AATF would be enacted around 2027.

To become an AATF, institutions or companies need to implement proper processing and dismantling activities. The requirements must comply with certain infrastructure and technological levels. Examples of requirements for infrastructure are bunkers, gradient

level floors, oil traps to guarantee the safe disposal of waste, and scheduled waste storage rooms. The above-mentioned AATF guidelines are not in public; therefore, AATF applicants receive technical advice from MARii. AATF applicants need to submit proposals to MARii; MARii reviews these proposals and promotes their approval to the Department of Environment. The AATF certification flow is in Figure A2.4.

The National Occupational Skills Standard on ELV is being developed, focussing on the skills and knowledge required to perform competently in the automotive parts and components salvaging and recycling industry. The standard is expected to help ensure environmentally responsible ELV processing in Malaysia. Under MS 2697:2018, the skilled manpower will be certified with a Malaysian Skills Certificate Level 3 based on this standard.

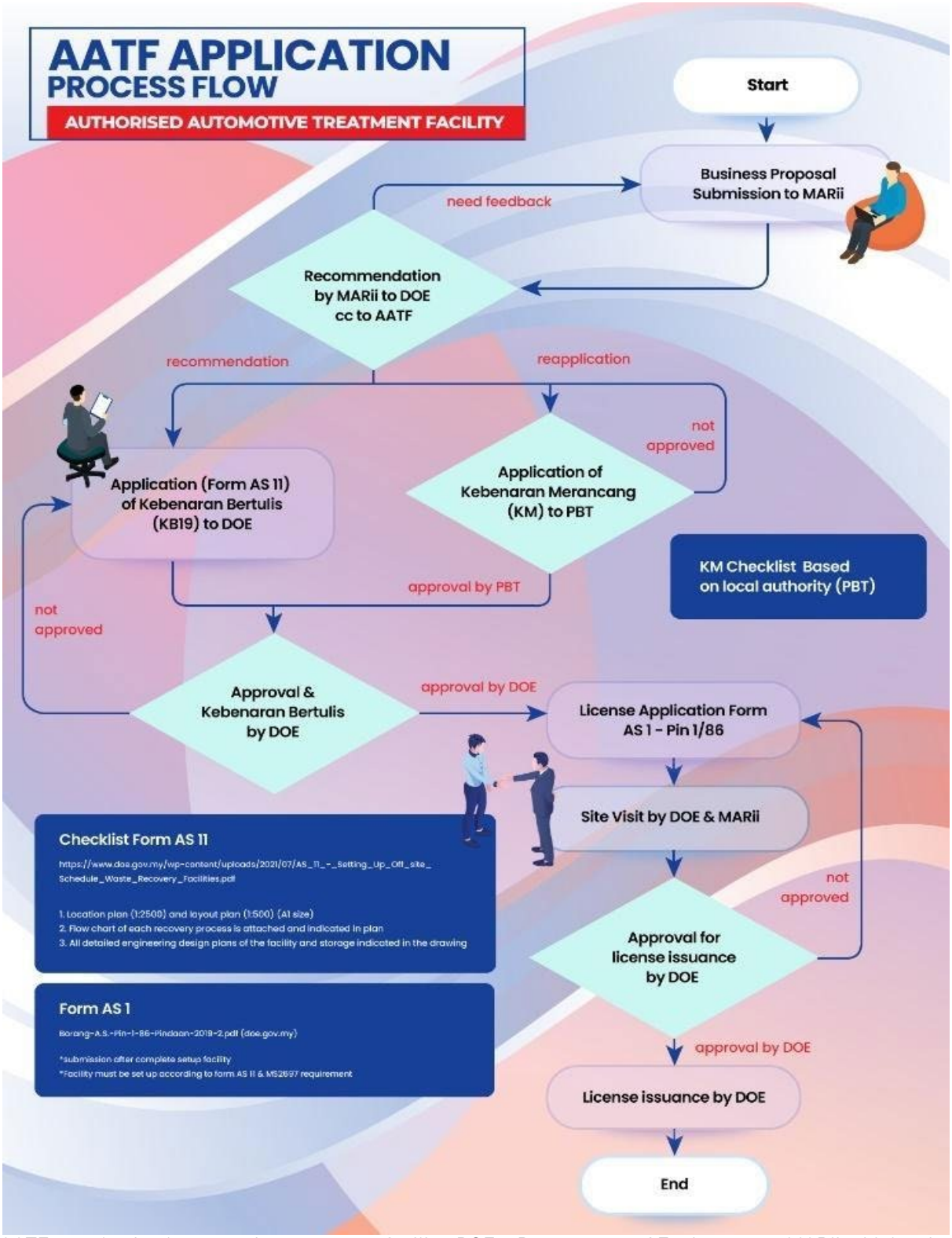
Companies that are involved in the recovery of waste through recycling are required to obtain a manufacturing licence under the Industrial Coordination Act, 1975. Applications should be submitted to Malaysian Industry Development Authority. Metal recyclers must be licensed under the Second-Hand Dealers Act 1946, which must be displayed at the operator's premises. This is particularly important when dealing with a mobile operator who collects materials directly from sellers.

There are incentives for companies for undertaking waste-recycling activities:

Pioneer status. This constitutes an income tax exemption of 70% of the statutory income for 5 years. Unabsorbed capital allowances as well as accumulated losses incurred during the pioneer period can be carried forward and deducted from the post-pioneer income of the company.

Investment tax allowance. This represents a 60% allowance on the qualifying capital expenditure incurred within 5 years. The allowance can be offset against 70% of the statutory income in each year of assessment. Any unutilised allowance can be carried forward to subsequent years until fully utilised.

Figure A2.4. Authorised Automotive Treatment Facility Application Process Flow, Malaysia



AATF = authorised automotive treatment facility, DOE = Department of Environment, MARii = Malaysia Automotive Robotics and IoT Institute, PBT = *pihak berkuasa tempatan* (local authority).
Source: MARii, 'Authorised Automotive Treatment Facility (AATF) Application', https://marii.my/authorised-automotive-treatment-facility-aatf-application/

2.6. Recycling Facilities

The Solid Waste and Public Cleansing Management Act 2007 defines solid waste management facilities as

> any land, fixed or mobile plant and systems incorporating structures, equipment used or intended to be used for the handling, storage, separation, transport, transfer, processing, recycling, treatment and disposal of controlled solid waste and includes transfer stations, disposal sites, sanitary landfill, incinerators and other thermal treatment plants, recycling plants and composting plants.

To build a solid waste management facility, director-general approval is needed regarding plans and specifications of the facility. If the facility owner fails to do so, he/she could be fined MYR100,000 and face up to 5 years in prison.

Moreover, AATF must be certified under MS 2697:2018, which specifies requirements for 4R activities of vehicle parts and components, including material and core recovery, processing, and handling. AATF, workshops, and spare parts operators that meet the standard ensure the quality and reliability of repairs; improve efficiency and performance, optimise operations, and reduce costs; enhance consumer confidence in their services; gain recognition in local and international markets through adherence to standards; and enhance personnel skills and competency through various certifications (Sirim Qas International, 2023)

MARii noted that the government is finalising guidelines on best practices for AATF licensing as of October 2024. The guidelines will ensure that AATF comply with all the standards and regulations that have been stipulated in Malaysia, such as the MS 2697:2018 and other acts and standards enforced by the Ministry of Transport, Ministry of Natural Resources and Environmental Sustainability, and Ministry of Housing and Local Development. A study on AATF policy development will also be led by MARii.

3. Philippines

3.1. Vehicle Registration

Various legislation on vehicles has been issued in the Philippines. The Republic Act on Land Transport, Land Transportation and Traffic Code (Republic Act No. 4136) was issued in 1964, and the Republic Act on Energy, Energy Efficiency and Conservation Act of 2018 and its implementing rules and regulations were issued by the Department of Energy. The EV Industry Development Act of 2022 and its implementing rules and regulations cover energy issues of vehicles. The Republic Act on the Environment, Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 and its implementing rules and regulations (DENR DAO 1992-29), Philippine Clean Air Act of 1999 and its implementing rules and regulations (DENR DAO 2000-81), Ecological Solid Waste Management Act of 2000 and its implementing rules and regulations (DENR DAO 2001-24), as well as the EPR Act of 2022 and its implementing rules and regulations (DENR DAO 2023-02) have also been promulgated. The Republic Act on Fiscal Incentives for Innovative Business and Corporate Recovery and Tax Incentives for Enterprises Act (CREATE) in 2021, which also relate to vehicles, have been issued. Republic Act No. 4136, known as the National Law on Traffic, is the main act that controls vehicle operations in the Philippines, including the registration and inspection of vehicles. (Kojima, 2018).

Bills in the House of Representatives. From July 2022 to 2025, relevant bills regarding vehicles in the House of Representatives include HB 4714, prioritising domestically manufactured vehicles in public procurement; HB 4791, establishing an online information centre on recalls, prohibitions, defects, and other safety-related data on consumer products and motor vehicles; HB 7404, creating a period of validity for the registration of motor vehicles, amending the Land Transportation and Traffic Code; HB 7738, supporting increasing annual sales targets on EV, hybrid EV (HEV), and alternative fuel vehicles, and providing incentives therefore, thus achieving 100% EV sales by 2040; HB 8570, establishing a special licence plate number for EV in the Philippines; and HB 8974, defining the classification, registration, and operation of all types of EV.

Department Administrative Orders. Departments issued administrative orders and programmes to implement the various legislation. The Department of Transportation issued Department Order No. 2020-021 (Guidelines for the Scrapping of Old Public Utility Vehicle Units) and implementing guideline LTO-LTFRB JMC 2021-001 to exchange old jeepneys for new, modernised vehicles. Moreover, the Department of Energy issued the *Philippine Energy Plan (PEP) 2030–2050,* Government Energy Management Program (GEMP), *Alternative Fuels and Energy Technologies Roadmap 2017–2040*, and *Comprehensive Roadmap for the Electric Vehicle Industry (CREVI).* The Department of Environment and Natural Resources issued *Technical Guidelines for Specific Categories of Treatment, Storage, and Disposal (TSD) Facilities* to control waste management, and the National Economic Development Authority developed the National Transport Policy and its implementing rules and regulations and *Philippine Action Plan for Sustainable Consumption and Production (PAP4SCP)*.

Starting in April 2015, the Department of Transportation and the Land Transportation Office (LTO) enforced the No Registration-No Travel Policy for vehicles, entailing that all vehicles must be registered to be on the road. Registration is conducted at the LTO. Registrations are valid for 3 years.

On renewing registration, users need to pay a vehicle usage charge. Rates were set by Republic Act No. 8794, depending on gross vehicle weight and vehicle classification (Table A2.6). The rate is different for specific vehicles such as taxis and cars registered before the act came into effect (Kojima, 2018).

Table A2.6. Vehicle Usage Charges, Philippines

(PHP)

Charge	Amount
Initial fee	1,000
Stickers and tags	50
New plate number	450
Inspection	90–115
Penalty (failure to get car inspected)	50
Other	Varies according to size: • Light vehicles: Passengers cars up to 1,600 kg • Medium vehicles: Vehicles 1,601–2,300 kg • Heavy vehicles: Vehicles 2,301 kg or higher

kg = kilogram.

Source: LTO, 'What Are the Requirements for Motor Vehicle Registration?', https://ltoportal.ph/requirements-motor-vehicle-registration/

Transfer of registration. The ownership of a car can be changed through the submission of required documents such as the original copy of the deed of sale at an LTO district office. According to the provisions of Batas Pambansa Blg. 43, the licence plate associated with the vehicle cannot be changed (Kojima, 2018).

Re-registration. Owners can re-register their vehicles at any LTO district office. The schedule of re-registration depends on the vehicle's plate number (Tables A2.7 and A2.8). The last digit of the plate number defines the month of the registration while the middle digit indicates the weekly deadline.

Table A2.7. Schedule of Re-registration Months, Philippines

Month	Plate's Last Number
January	1
February	2
March	3
April	4
May	5
June	6
July	7
August	8
September	9
October	0

Source: LTO, 'What Are the Requirements for Motor Vehicle Registration?', https://ltoportal.ph/requirements-motor-vehicle-registration/

Table A2.8. Schedule of Re-registration Weeks, Philippines

Date (Working Day)	Plate's Middle Digit
1–7	1, 2, 3
8–12	4, 5, 6
13–21	7, 8
22–31	9, 0

Source: LTO, 'What Are the Requirements for Motor Vehicle Registration?', https://ltoportal.ph/requirements-motor-vehicle-registration/

Deregistration. There is a deregistration system, but few people use it. Registered vehicles are required to be re-registered every year; however, this does not apply to inactive cars. If owners want such cars to become active again, they need to renew the registration and pay the accumulated renewal fees (Kojima, 2018).

3.2. End-of-life Vehicles

In the Philippines, the age limits for public vehicles are 15 years for utility vehicles, 15 years for buses, 13 years for unleaded fuel or diesel taxis, 15 years for LPG tais, and 15 years for trucks. The government launched the Public Utility Vehicle Modernization Program in 2017 to help change the landscape of public transport in the country. Under this programme, the age limit of jeepneys was set at 15 years and is expected to generate many used jeepneys in future (CPBRD, 2020).

Private vehicle deregistration and renewal are not explicitly based on vehicle age or type but are usually based on emissions testing results.

3.3. Recycling

According to the implementing guidelines (LTO-LTFRB Joint Memorandum Circular No. 001 2021), vehicle scrapping facilities must possess a dismantling area, storage area for recyclable products, temporary storage area for hazardous waste, office area, and parking. The scrapping facility must facilitate the scrapping/dismantling of ELV within 6 months upon submission by the operator or letter of intent duly stamped, received, and acknowledged by the regional secretariat. A scrapping certificate is issued to the operator or cooperative/corporation by the scrapping facility upon completion of the vehicle scrapping process. The operator or cooperative/corporation must submit a copy with proof of scrappage to the regional secretariat.

Collection systems for refrigerants, ozone-depleting substances, and CFC were established as a response to the Montreal Protocol by the Philippine Ozone Desk. Destruction facilities or technologies for CFC are mostly associated with thermal destruction through cement kilns registered as treatment, storage, and disposal facilities. However, the logistics for collection is limited.

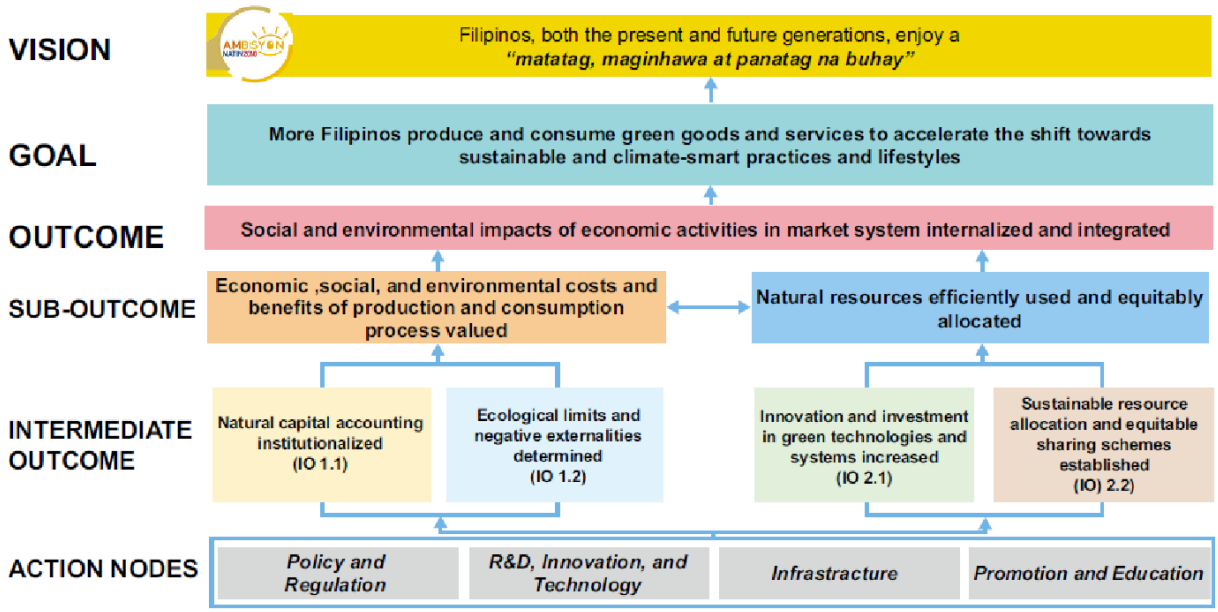
Republic Acts No. 6969 and 9003 define general waste recycling in the Philippines. In addition, Republic Act No. 11898 was implemented in 2022 to achieve plastic neutrality and requires enterprises to register with the National Solid Waste Management

Commission their EPR programmes to reduce and/or to recover for reuse, recycling, treatment, or proper ecological disposal the plastic packaging waste that they release or have released to the domestic market. It focusses more on addressing plastic packaging, but this may be used as the template for future laws that will cover other waste types in the future such as ELV.

To achieve plastic neutrality, obligated enterprises may include in their EPR programme the activities and strategies enumerated in Section 44-A, of Republic Act No. 9003, as amended by Republic Act No. 11898. These are (i) reduction of non-environmentally friendly products that may include adoption of reusable products or redesign to improve reusability, recyclability, or retrievability; inclusion of recycled content or recycled materials in a product; adoption of appropriate product-refilling systems for retailers; viable reduction rate plans and education campaign schemes; and appropriate labelling of products, including information on the proper disposal of the waste product; and (ii) product waste recovery programmes aimed at effectively preventing waste from leaking into the environment, which may include waste recovery schemes through redemption; buy-back, offsetting, or any method or strategy that will efficiently result in the high retrievability, high recyclability, and resource recovery of waste products; diversion of recovered waste into value chains and value-adding products through recycling and other sustainable methods; transport of recovered waste to the appropriate composting, recycling, or other diversion or disposal site in the country; establishment of commercial- or industrial-scale recycling, composting, thermal treatment, and other waste diversion or disposal facilities for waste products when investment is viable; and partnerships with local government units, communities, and the informal waste sector towards their goals.

In addition, the National Economic and Development Authority developed the PAP4SCP, with assistance from the Asian Development Bank, to influence sustainable practices and behaviours across sectors and levels of government (NEDA, 2023). It includes programmatic interventions, including circular economy approaches, geared towards decoupling the country's economic growth from environmental degradation under the new normal brought about by the COVID-19 pandemic. The PAP4SCP embodies a comprehensive framework covering policy, research and development, innovation, technology, infrastructure investments, and information and education to enjoin consumers and producers to adopt sustainable strategies and practices. Figure A2.5 outlines its vision, goal, and outcomes.

Figure A2.5. PAP4SCP Strategic Framework



PAP4SCP = Philippine Action Plan for Sustainable Consumption and Production, R&D = research and development.
Source: NEDA (2023).

Table A2.9 is a sample of the actions listed in the PAP4SCP, while Figure A2.6 shows a timeline for implementation. Institutionalised EPR schemes for other waste streams (e.g. e-waste, lighting products) are also planned as medium-term actions. It is possible that EPR be applied to batteries and/or vehicles in the future.

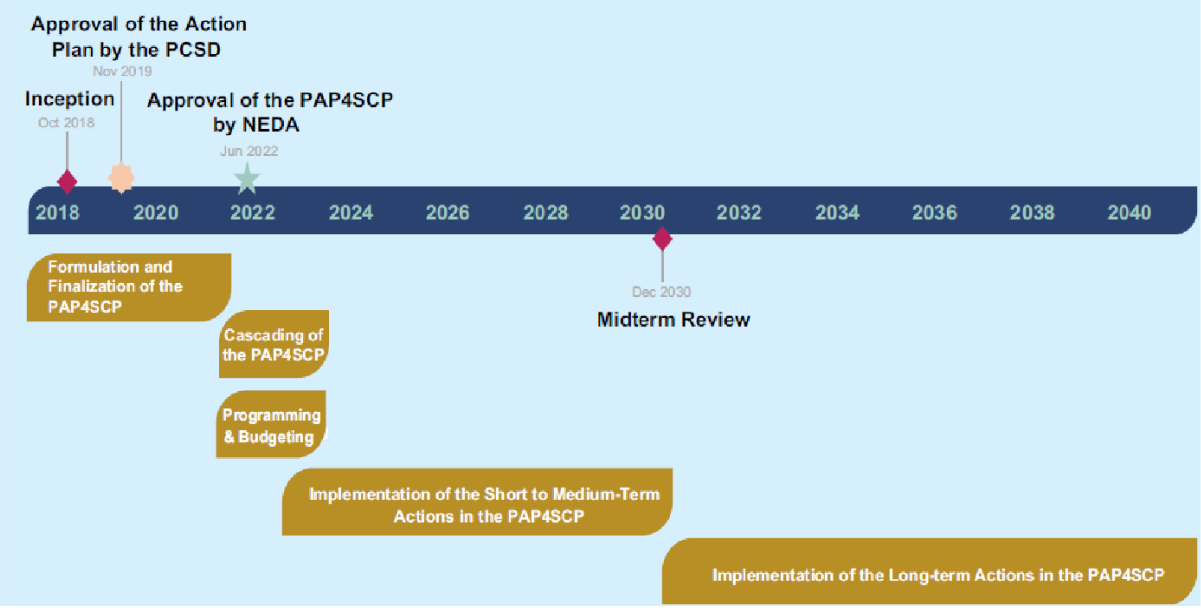
Table A2.9. Actions listed in PAP4SCP

Short-term (2022–2023)	Medium-term (2024–2030)	Long-term (2031–2040)	Responsible Agencies
Implement 'choice-editing' strategies Streamline eco-labelling systems			
Integrate innovation/green technologies in updating the Green Building Code	Enact local green building ordinances to enforce sustainable building designs for public and private facilities	Review and evaluation policy implementation	DPWH, LGUs, CCC
Implement the EPR Act for plastic packaging that incorporates the polluter-pays principle by obliging	Institutionalise EPR schemes for other waste systems (e.g.	Review and evaluation policy implementation	DTI, SEC, LGUs, Congress, DENR,

Short-term (2022–2023)	Medium-term (2024–2030)	Long-term (2031–2040)	Responsible Agencies
large enterprises to conduct EPR programmes and to link to companies' sustainability reports Develop sustainability reporting or equivalent guidelines for medium-sized enterprises	e-waste and lighting products) Support industries and startups to develop alternative products with minimal residual and longer utility Adopt and implement sustainability reporting guidelines for medium-sized enterprises Undertake a third-party audit to monitor and to verify sustainability reports of publicly listed companies		NSWMC, private sector

DENR = Department of Environment and Natural Resources, DPWH = Department of Public Works and Highways, DTI = Department of Trade and Industry, EPR = extended producer responsibility, LGU = local government unit, NSWMC = National Solid Waste Management Commission, PAP4SCP = *Philippine Action Plan for Sustainable Consumption and Production,* SEC = Securities and Exchange Commission.
Source: NEDA (2023).

Figure A2.6. Timeline of Finalisation and Implementation of the PAP4SCP



NEDA = National Economic and Development Authority, PAP4SCP = *Philippine Action Plan for Sustainable Consumption and Production*, PCSD = Philippine Council for Sustainable Development.
Source: NEDA (2023).

3.4. Waste Management

There are two main regulations on waste management.

Ecological Solid Waste Management Act (Republic Act No. 9003, 2001). Established as the basic law for waste management, the law stipulates that local government units are responsible for solid waste management, promotes the 3R, and defines waste management policies. Local government units plan and implement waste management in accordance with this law. In addition to stipulating the transfer of inappropriate final disposal sites to sanitary landfills, waste is to be reduced at the source.

Toxic Substances, Hazardous and Nuclear Wastes Control Act (Republic Act 6969, 1990). This law stipulates the management of the importation, manufacture, process, distribution, use, transport, treatment, and final disposal of hazardous materials and hazardous/radioactive materials. The definition of hazardous waste under this law is materials that have no safe commercial, industrial, agricultural, or economic use and are transported or brought into Philippine territory from the country of origin for the purpose of dumping, disposal, or transit. This also includes by-products, process residue, spent reaction media, contaminated facilities or equipment, other materials resulting from industrial activities, and industrial products disposed of by consumers (Tsuruoka, 2023).

3.5. Licences for Recyclers

Junkshop and scrap businesses should register and obtain licences of operation from municipalities (BMSMED, 2010).

3.6. Recycling Facilities

In implementing Republic Act No. 6969, Department of Environment and Natural Resources Administrative Order 2013-22 prescribes the governing rules and regulations for hazardous waste treatment, storage, and disposal facilities. It also includes the categorisation of such facilities: Category A, on-site treatment and disposal facilities, Category B, thermal treatment facilities, Category C, disposal facilities (Table A2.10); Category D, recycling facilities; Category E, chemical treatment facilities; Category F, storage facilities; and Category G, facilities that decommission polychlorinated biphenyl-containing equipment.

Table A2.10. Allowable Hazardous Wastes per Disposal Method for Category C Treatment, Storage, and Disposal Facilities

Type	Description	Allowable Hazardous Wastes	
Sanitary Landfill	Excavated or engineered sites where non-liquid hazardous wastes are deposited for final disposal. These sites are selected and designed to minimise the chance of release of hazardous waste into the environment. Liquid wastes cannot be disposed into a hazardous waste sanitary landfill.	K301	Solidified waste
		K302	Chemically fixed and polymerised waste
		K303	Encapsulated waste
		M501	Pathological or infectious waste*
		M502	Asbestos waste
		M506	Waste electrical and electronic equipment
Surface Impoundments	Natural topographic depressions, human-made excavations, or diked areas formed primarily of earthen materials used for storage and treatment of liquid hazardous waste. Examples include holding, storage, settling, aeration pits, ponds, and lagoons.	M505	Persistent organic pollutant waste

*Only pathological or infectious wastes that have undergone treatment by a registered TSD facility may be disposed of in a sanitary landfill.
Source: EMB (2015).

The technical specifications per hazardous waste disposal method prescribed in Table A2.11 are used by Category C facilities.

Table A2.11. Technical Specifications per Disposal Method

Unit	Specifications
Sanitary Landfill	
Double Liner	Must consist of a top liner to prevent migration of hazardous constituents into the liner and a composite bottom liner consisting of a synthetic geomembrane and 3 feet of compacted soil material.
Double LCRS	Primary LCRS must be located above the top liner, while secondary LCRS must be located between the liners immediately above the bottom composite liner. Secondary LCRS, which also serves as the leak detection system, must be designed with a bottom slope of at least 1%, made of materials chemically resistant to the waste placed in the unit, and have the ability to remove the liquids. Must be designed to collect liquids in a slump and subsequently pump out those liquids.
Others	Must have storm water run-on and run-off controls to prevent migration of hazardous constituents for at least a 25-year storm and a cover to prevent wind dispersal.
Surface Impoundments	
Impoundment Unit	Must be designed to prevent the flow of liquids over the top of an impoundment (or overtopping) and to ensure the structural integrity of any dikes.
Double Liner	Must consist of a top liner to prevent migration of hazardous constituents into the liner and a composite bottom liner consisting of a synthetic geomembrane and 3 feet of compacted soil material.
LCRS	Must be located between the liners immediately above the bottom composite liner, enabling the LCRS to collect the largest amount of leachate, while also representing the most efficient place to identify leaks. Must be designed with a bottom slope of at least 1%, be made of materials chemically resistant to the waste placed in the unit and have the ability to remove the liquids. Must be designed to collect liquids in a slump and subsequently pump out those liquids.

LCRS = Leachate Collection and Removal System.
Source: EMB (2015).

Facilities that recycle or reprocess hazardous waste, which is not generated nor produced at the facility, are classified as Category D facilities. These include facilities that recover valuable materials (i.e. used or waste oil, solvents, acids, alkalis, and metals); use hazardous waste as input materials or as alternative fuel for industrial processes; or remediate contaminated soil through physical, chemical, or biological treatment. Table A2.12 presents permissible hazardous wastes per recycling method for Category D facilities.

Table A2.12. Permissible Hazardous Waste per Recycling Method for Category D Treatment, Storage, and Disposal Facilities

Type	Description	Allowable Hazardous Waste	
Recycling Constituting Disposal	Applying a hazardous waste directly to the land or incorporating it into a product that will be applied to the land, such as for landfilling, backfilling, and composting	H802	Grease waste
Combustion of Recovered or Alternative Fuel	Burning of hazardous waste directly as an alternative fuel or using it as an ingredient or input material to produce fuel for industrial processes	G704	Non-halogenated organic solvents
		H802	Grease waste
		I101 to I104	Used or waste oil
Reclamation	Reprocessing of hazardous waste to recover a usable product or to remove contaminants in a way that restores the waste to a usable condition such as bioremediation (e.g. microbial reduction, phytoremediation), physical extraction (e.g. filtration, air stripping, dewatering), chemical extraction, and thermal extraction	A101	Waste with cyanide
		D401	Selenium and its compounds
		D403	Barium and its compounds
		D404	Cadmium and its compounds
		D405	Chromium compound
		D406	Lead compounds
		D407	Mercury and mercury compounds
		F601	Solvent-based
		F602	Inorganic pigments
		F603	Ink formulation
		F604	Resinous materials

Type	Description	Allowable Hazardous Waste	
		G703	Halogenated organic solvents
		G704	Non-halogenated organic solvents
		H802	Grease waste
		I101 to I104	Used or waste oil
		L401	Waste with specific halogenated toxic organic chemicals
		L402	Wastes with specific non-halogenated toxic organic chemicals
		M501	Pathological or infectious wastes
		M504	Pesticides
		M506	Waste electrical and electronic equipment

Source: EMB (2015).

The technical specifications per hazardous waste recycling method prescribed in Table A2.13 are used by Category D facilities.

Table A2.13. Technical Specifications per Recycling Method

Unit	Specifications
Recycling Constituting Disposal	
Storage Unit	Subject to the technical specifications prescribed in Table 9 in the Technical Guideline
Hazardous Waste	Must be treated to reduce its toxicity and ability to leach into soil and groundwater before the waste is applied to land
Combustion of Recovered or Alternative Fuel	
Storage Unit	Subject to the technical specifications prescribed in Table 9 in the Technical Guideline
Combustion Equipment	Must be permitted by the Department of Labor and Employment and meet performance and operating standards of boiler and industrial furnace regulations
By-product	Subject to the technical specifications prescribed in Table 3 in the

Unit	Specifications
Disposal	Technical Guideline
Reclamation	
Storage Unit	Subject to the technical specifications prescribed in Table 9 in the Technical Guideline
Reclamation Unit	Must be able to completely recover a usable product or restore it to a usable condition
By-product Disposal	Subject to the technical specifications prescribed in Table 3 in the Technical Guideline

Source: EMB (2015).

4. Singapore

4.1. Vehicle Registration

The Road Traffic (Motor Vehicles, Registration and Licensing) Rules of Singapore define policy and regulation of registration, transfer, re-registration, and deregistration of vehicles. The applied policies are explained on OneMotoring, which is authorised by the Land Transport Authority (LTA).

In Singapore, even the introduction of high taxes for vehicles has not succeeded in reducing the number of vehicles on the road. To overcome this problem, in 1990, the Vehicle Quota Scheme (VQS) was introduced. The system operates through the open auction of certificates of entitlement (COE) for various types of vehicles. A vehicle buyer must have a COE before being allowed to purchase a vehicle. The VQS classifies vehicles into five COE categories as shown in Table A2.14.

Table A2.14. Certificate of Entitlement Categories, Singapore

Category	Details
A	For COE obtained before the May 2022 1st COE bidding exercise: Cars with engine capacity up to 1,600 cc and maximum power output up to 97 kW (130 bhp) For COE obtained from the May 2022 1st COE bidding exercise onwards: Non-fully electric cars with engines up to 1,600 cc and maximum power output up to 97 kW (130 bhp); and fully electric cars with maximum power output up to 110 kW (147 bhp)
B	For COE obtained before the May 2022 1st COE bidding exercise: Cars with engine capacity above 1,600 cc or maximum power output above 97 kW (130 bhp) For COE obtained from the May 2022 1st COE bidding exercise onwards: Non-fully electric cars with engines above 1,600 cc or maximum power

Category	Details
	output above 97 kW (130 bhp) and fully electric cars with maximum power output above 110 kW (147 bhp)
C	Goods vehicles and buses
D	Motorcycles
E	Open – all except motorcycles

bhp = brake horsepower, cc = cubic centimetre, COE = certificate of entitlement, kW = kilowatt
Source: LTA, 'Certificate of Entitlement (COE)', OneMotoring, https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/certificate-of-entitlement--coe-.html

Every year, LTA announces how many COE quotas are available in each category. After receiving a COE, a vehicle can be purchased and registered for 10 years. The certificate must be stay with the vehicle even if it is sold before the 10-year duration. After 10 years, the owner can choose to cancel the registration or keep the certificate by paying the prevailing quota premium for the vehicle category. Once the vehicle has reached the statutory lifespan, however, the vehicle owner can no longer renew the COE.

Registration. All vehicles in Singapore require a COE as described above. Singapore's VQS uses uniform-price auctions to distribute COE or registration rights for various vehicle classes. The cost of vehicle ownership is determined directly by the market under the VQS, as the prices of both quota licence premiums and vehicles fluctuate in response to market demand (Jamaluddin et al., 2022).

The quota for new vehicles is determined following a targeted rate of growth in the vehicle population and considering the projected vehicle deregistration numbers. Between 1975 and 1989, the average annual vehicle population growth rate was 4.40%, but this fell to 2.83% between 1990 and 2002 (Tan, 2003). As a result, the VQS was able to reduce both the vehicle population and its volatility.

Transfer of registration. When one buys or sells a second-hand vehicle, the registration must be transferred to the new owner within 7 days. Transfer of car ownership is a legal requirement in Singapore and must be done promptly to ensure proper documentation and ownership records. There are specific fees involved for the transfer, and necessary documents must be submitted to the LTA.

Re-registration. At the end of the first 10 years of a COE, the owner may either deregister the vehicle or renew the licence for a further 5- or 10-year period, by paying the prevailing quota licence premium. Following that, no further renewals are permitted. The process involves certain fees and documentation, including proof of compliance with vehicle safety and emissions standards. For renewal of a COE for 5 years, the owner pays 50% of prevailing quota licence premium or 100% when renewing for 10 years.

Table A2.15. Certificates of Entitlement per Car Age

Age of Car	COE
< 10 years	Buyer takes over the remaining COE. Buyer will also inherit any rebates attached to the vehicle
≥ 10 years	Buyer needs to renew the COE for the vehicle. COE may be renewed in 5- or 10-year blocks

COE = certificate of entitlement.
Source: LTA, 'Certificate of Entitlement (COE)', OneMotoring, https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/certificate-of-entitlement--coe-.html

Deregistration. When a vehicle deregistered, it must be scrapped, exported, or stored temporarily in an export-processing zone pending export. If a vehicle is deregistered, exported, or scrapped before the expiry of the quota licence, the owner is entitled to a rebate based on the quota licence premium that was paid, and this is prorated according to the remaining validity period of the quota licence.

Within 1 month of deregistering a vehicle, proof must be submitted that the vehicle has been scrapped, exported, or sent to an export-processing zone for storage. Failure to do so may result in prosecution and a fine of SGD2,000 or 3-months' imprisonment. If convicted more than once, the fine can be raised to SGD5,000 or imprisonment up to 6 months.

It is a violation of regulations for anyone to drive a deregistered vehicle. Offenders will be prosecuted in court and face a fine of up to SGD2,000, up to 3 months in prison, or both. A deregistered vehicle must be towed to move it from one location to another.

Inspection. Regular vehicle inspections are required when a vehicle is 3 years old. Vehicles must be inspected every 2 years until they are 10 years old, after which inspections are required annually (Table A2.16). Inspections ensure that all vehicles on the road meet safety and emissions standards set by LTA. Inspections must be conducted at authorised inspection centres, which are listed on OneMotoring.

Table A2.16. Vehicle Inspection Frequency, Singapore

Vehicle Type	Vehicle Age		
	< 3 Years	3–10 Years	> 10 Years
Motorcycle/Scooter		Annually	Annually
Car		Every 2 Years	Annually
Tuition Car	Annually	Annually	Annually
Taxi	Every 6 Months	Every 6 Months	
Chauffeured Private Hire Car	Annually	Annually	Annually
Omnibuses	Every 6 Months	Every 6 Months	Every 6 Months
Other Buses	Annually	Annually	Every 6 Months
Goods Vehicles	Annually	Annually	Every 6 Months
Trailers	Annually	Annually	Annually

Source: LTA, 'Vehicle Types and Registration', OneMotoring, https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/vehicle-types-and-registrations.html

Insurance. All vehicles must have insurance coverage in Singapore. It is a requirement for a vehicle to be insured for the entire road tax renewal period before its road tax can be renewed. Insurance must at least cover third-party liability for deaths and bodily injury. This requirement is based on the Motor Vehicles (Third-Party Risks and Compensation) Act 1960, which was last revised in 2020.

4.2. End-of-life Vehicles

When a vehicle is deregistered and will not be exported, it must be disposed of by an LTA-appointed scrapyard. Furthermore, if a vehicle is found and has already been deregistered, anyone can tow or transport the vehicle to an LTA-appointed scrapyard with a national registration identity card (for Singaporeans and permanent residents) or employment/Immigration pass card (for foreigners).

Singapore, despite having no ELV regulations, has successfully reduced the number of ELV and has avoided vehicles proceeding to ELV status by practicing a quota system to limit the number of vehicles in the country.

4.3. Recycling

As for waste collectors, the details for their licences were settled in the Environmental Public Health Regulations. Scrapyards in Singapore need to be authorised by LTA.

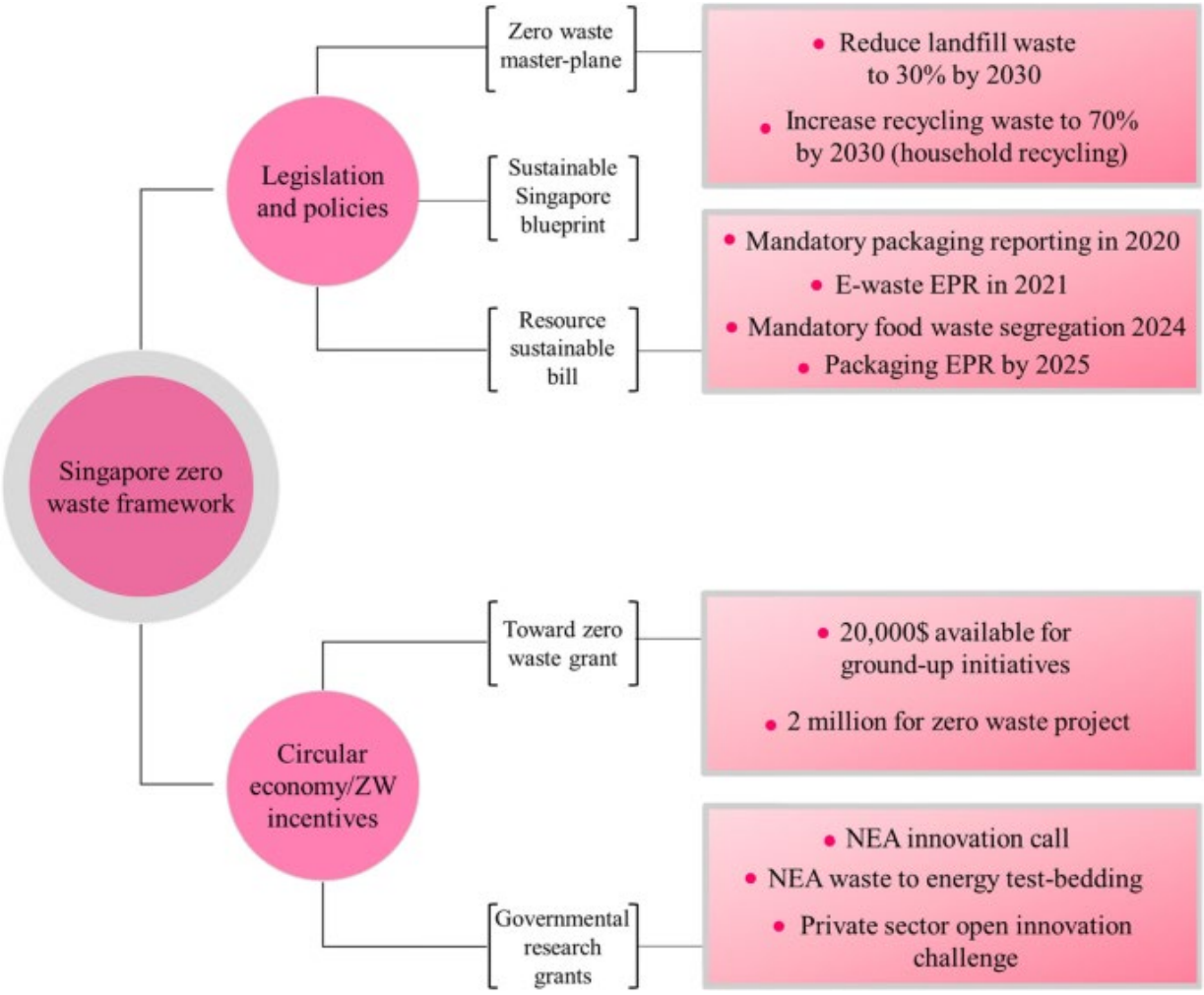
According to the Resource Sustainability Act, which came into effect in 2021, the collection of e-waste, including batteries, falls under a producer responsibility scheme. It requires that the operator, which is appointed by National Environment Agency (NEA) through open tender, to develop and to implement a system to organise the collection and

recycling of consumer products on behalf of producers. All retailers of regulated consumer products are required to provide free one-for-one take-back services during delivery. Large retailers (i.e. with floor areas of 300 square metres and above) are required to set up in-store e-waste collection points for information and communication technology equipment, lamps, and batteries, and to ensure that the e-waste is collected by the operator.

Producers must register with NEA and report the number of regulated products that they supply to the local market annually. For producers of EV and HEV batteries that produce at least 15 tonnes, an exact fee needs to be submitted to the operator to finance the necessary operation. The detailed amount is decided by NEA according to the market share of supply, which is reported to NEA annually.

Singapore is working to establish a circular economy in which it can increase incineration plant capacity along with more recycling and to minimise carbon emissions from incineration. The year 2019 was the beginning of a zero-waste master plan in Singapore by decreasing the consumption rate through reuse and recycling. Under this plan, the target is to reduce landfills by 30% by 2030. In addition, there are new obligations for the collection and treatment of electronic and food waste in Singapore, including mandatory packaging by 2020, expanding the responsibility of producers for electronic waste by 2021, mandatory treatment of food waste by 2024, and increasing producer responsibilities for packaging especially with plastics by 2025 (Figure A2.7).

Figure A2.7. Singapore Zero-waste Framework



EPR = extended producer responsibility, NEA = National Environmental Agency.
Source: Ghomi et al. (2021).

4.4. Waste Management

In 2021, Singapore published three regulations based on the Resource Sustainability Act. All are related to the collection and recycling of e-waste.

Resource Sustainability (E-waste Recyclers) Regulation 2021. This regulation sets out various requirements for e-waste recyclers. For the five types of products (i.e. batteries, information and communications technology equipment, large appliances, solar photovoltaic panels, and specified single-phased lamps) stipulated, the material recovery targets in Table A2.17 must be adhered to when recycling them.

Table A2.17. Material Recovery Targets by Product, Singapore

Regulated Product	Material Recovery Target
Batteries	50%
ICT equipment	70%
Large appliances	80%
Solar photovoltaic panels	70%
Specified single-phased lamps	80%

ICT = information and communications technology.
Source: Government of Singapore (2024).

In addition, the regulation includes data erasure. Recyclers who receive e-waste are required to permanently erase or to destroy the data stored in the e-waste before reusing, recycling, disposing, or transferring it out of the facility. Violation of this regulation will result in a fine of up to SGD10,000. Furthermore, recyclers must keep relevant records for 5 years to prove that they have complied with the requirements stipulated in the regulations.

Resource Sustainability (In-store Collection of E-waste) Regulation 2021. This regulation provides for the collection of e-waste in retail outlets. Large retailers are required to provide collection boxes or a manual collection service at their premises. The collection boxes must be provided by an authorised operator based on the producer responsibility scheme or must be of the same design and specifications as the said boxes. Requirements for in-store collection of e-waste cover small electrical and electronic equipment (e.g. printers, mobile phones, personal computers, and modems), portable batteries, and consumer lamps.

Resource Sustainability (Prescribed Regulated Products) (Amendment) Regulation 2021. This regulation replaces the First Schedule of Resource Sustainability Regulation, 2019. The supply thresholds of products that require producers to join the producer responsibility scheme are tightened for some products. For example, for modems, the previous threshold was 10 tonnes, but this revision was tightened to 200 kilograms. This means that producers who would not have been subject to the producer responsibility scheme under the previous regulations may now be subject to it.

4.5. Licences for Recyclers

Consumer products refer to equipment largely marketed to and bought or used by the general public (e.g. laptops, mobile phones, and household appliances). NEA will appoint one producer responsibility scheme operator to develop and to implement a system to organise the collection and recycling of consumer products on behalf of producers. The operator will be appointed through open tender, and the winning bidder will be required to develop programmes to encourage the public to recycle e-waste, provide avenues for e-waste recycling (e.g. scheduled collection drives and e-waste bins in public areas), collect and transport the e-waste to NEA-licensed e-waste recyclers, and report the tonnage of e-waste collected to NEA.

The operator will be responsible for meeting e-waste collection targets set by NEA. NEA has set the target for large household appliances at 60% of the put-to-market weight, and the target for the rest of the covered consumer products is at 20% of the put-to-market weight. As a transitional measure, penalties for missing enforcement targets will not be imposed for the first 3 years. Producers of consumer products will be required to join the producer responsibility scheme and to finance the collection and recycling of the e-waste.

As previously noted, the producer responsibility scheme will be financed by the producers of consumer products in proportion to their market share. The producers will hence be required to report to NEA the tonnage of regulated products that they put to market. NEA will exempt small producers and retailers that supply less than a specified threshold number of regulated products to the local market from the producer responsibility scheme. These producers are only required to register with NEA and to report the number of regulated products that they supply to the local market annually. Likewise, retailers with a floor area of less than 300 square metres will be exempt from setting up in-store collection points.

4.6. Recycling Facilities

All retailers of regulated consumer products will be required to provide free one-for-one take-back services during delivery. Large retailers are required to set up in-store e-waste collection points for information and communications technology equipment, lamps, and batteries, and to ensure that the e-waste is collected by the producer responsibility scheme operator.

5. Thailand

5.1. Vehicle Registration

The Department of Land Transport (DLT) under the umbrella of the Ministry of Transport oversees vehicle registration, transfer of registrations, re-registration, suspension, and deregistration.

Registration. In Thailand, all types of vehicles must be registered. Private inspection stations authorised by DLT carry out inspections of vehicles registered under the Motor Vehicle Act (i.e. motorcycles and taxis). Car owners must pay a road tax. Insurance is also required.

A vehicle is registered at a land traffic office that has jurisdiction over the owner's registered address. If the owner mostly wants to use the vehicle in some other area, he/she may have it registered at the land traffic office within such jurisdiction.

The fee for registration depends on the type and age of the vehicle. Typically, for a motorbike, it is around THB300–THB400. For a car, it starts at around THB1,000 (for engines up to 2,000 cubic centimetres) but it can go up to THB 7,000 for a 4-door pick-up truck and similar vehicles. The fee is the same each year for the first 5 years, then it is reduced by 10% every year up to a maximum of 50%.

Transfer of registration. Car owners are required to transfer registration due to change of ownership, vehicle colour, and/or engine.

Re-registration. Registration of cars is required every year, and the owner must show

certifications of automobile tax, inspection, and insurance at the time of registration.

Deregistration. Deregistration is obliged within 15 days after the owner has stopped using the vehicle. If an owner does not pay the registration fee for more than 3 years, the vehicle will be automatically deregistered. In case of the suspension of use of a registered car over 15 days, the owner is required to apply for re-registration.

The issue of abandoned vehicles has become more serious in recent years. Officials are required to spend 15 days attempting to locate the owner of an abandoned vehicle, failing which the vehicle will be impounded by the municipality. The vehicles are kept for approximately 6 months before being auctioned off by district office directors.

Inspection. At present, motorcycles and cars aged more than 5 and 7 years, respectively, must be inspected before their registrations can be renewed. The registration system relies on a logbook that is tied to the motorcycle or car.

DLT established a privately operated system of inspection stations in 1994. There are 225 centres in the Bangkok Metropolitan Region, including 169 centres in Bangkok. About 70% also repair vehicles. Personal vehicles are required to undergo inspection every year after 7 years from registration. Commercial vehicles must undertake an inspection every year after registration. The Ministry of Industry has supported the improvement of automotive testing centres, enabling them to conduct testing according to international standards as well as testing related to non-tariff measures to trade (e.g. ELV management and volatile organic compounds).

Figure A2.8. Inspection in Thailand

Inspection Process in Private Station

DIW Camera to Monitor Inspection Process

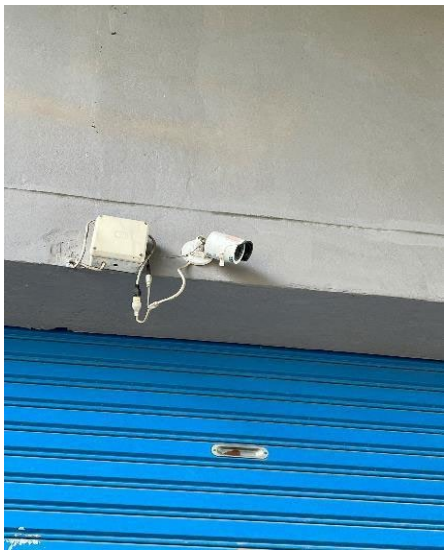


Figure A2.8. *Continued*

Inspection of Light

Inspection of Gas

DIW = Department of Industrial Works.
Source: Authors.

Insurance. Based on the Protection for Motor Vehicle Accident Victims Act B.E. 2535, any person who fails to subscribe to compulsory insurance or to renew the insurance in case of expiration can be fined THB10,000–THB50,000.

5.2. End-of-life Vehicles

Despite being the largest production hub for global car manufacturers and the second-largest domestic market for automobiles in South-east Asia after Indonesia, Thailand has no formal policy regarding ELV and no definition of ELV. However, the Government of Thailand is now working closely with the Japan International Cooperation Agency (JICA) on creating a recycling system for ELV and is expected to settle on the definition of ELV.

Although there is no direct law or regulations on ELV management in Thailand, there are several laws and regulations that govern ELV management activities such as the Act on the Maintenance of the Cleanliness and Orderliness, which is related to laws on waste management. Other laws include the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), Pollution Prevention and Mitigation Policy (1997–2016), and various environment standards.

Regardless of ELV management in Thailand, related laws and regulations as well as policy appear to inspire most people to prolong car usage without keeping their cars in good condition. This is caused by factors such as the presence of a market for second-hand car parts, annual tax registration renewal fees that are according to the length of vehicle ownership, and vehicle value at the time of disposal.

An initiative to address ELV recycling in Thailand began 4–5 years ago. The Ministry of Industry and Industrial Estate Authority of Thailand worked closely with the New Energy and Industrial Technology Development Organization to demonstrate the operation of an ELV recycling system using heavy machinery for vehicle dismantling. In collaboration with

Japan's Ministry of Economy, Trade, and Industry, the New Energy and Industrial Technology Development Organization is also working to provide guidance on developing laws and regulations related to the proper and safe handling of ELV suitable for Thailand based on Japan's Automobile Recycling Law. Concurrently, organisations like JICA and the Association for Overseas Technical Cooperation and Sustainable Partnerships have been involved in imparting such knowledge to Thailand, including study tours to Japan with participation from DLT.

Recently, JICA has committed to deploying experts to various Thai ministries to further these efforts. However, a formal project for ELV management has not been established, and coordination amongst DLT, Department of Industrial Works (DIW), and Pollution Control Department remains in progress to streamline ELV processing. There also have been challenges in assigning regulatory responsibilities; the Pollution Control Department has stated it will not draft legislation, suggesting that DIW should take on this role. Meanwhile, DLT is expected to be responsible for vehicle registration and plans to handle the administrative procedures related to ELV.

With JICA, a comprehensive overview and conceptual plan are expected to be developed, highlighting unmet tasks and clarifying the responsible departments by its next steering committee meeting. According to an interview conducted during the field study in September 2024, the establishment of permits, audits, tracking, and waste management will fall under DIW, with consulting support from another entity. Meanwhile, regulations on vehicle registration, deregistration, inspections, and tax enforcement will be under DLT, with support from Japanese agencies. The establishment of the system for recycling fees and financial management responsibilities will be assigned to the Fiscal Policy Office, DIW, and Thai Automotive Industry Association, with consultancy provided by experts from Japan. A proposal to divide responsibilities into three specific sub-working groups has also been made, with each expected to produce outputs monthly and report to the ELV Recycling Working Group quarterly.

Based on the above structure, further strategic direction has also been discussed. Vehicle dismantling regulations in Thailand, akin to Japan, are expected to require proper handling of three primary materials (i.e. fluorocarbons, airbags, and ASR) plus batteries and oil, including recycling fees collected for those parts. Furthermore, a tracking system for vehicles, which was suggested during the New Energy and Industrial Technology Development Organization project, is already in place, with data input possible via mobile phones or computers. The integration of vehicles into this system and financial management remain key challenges, however. Financial management will likely involve upfront payments by original equipment manufacturers or importers, with the Thai Automotive Industry Association suggested as the managing body. Payments to dismantlers and recyclers would be linked to the tracking system.

A new model during the discussions with the Japan Automobile Manufacturers Association will be proposed to the Thai Automotive Industry Association. A wholesale approach is recommended for setting fees for the three primary materials, and a licensing system akin to those in Japan and the European Union has been deemed necessary for ELV collection, while responsibility for battery removal will also be likely to fall under DIW.

5.3. Recycling

Various environmental regulations are imposed for controlling ELV recycling, including the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992); and Pollution Prevention and Mitigation Policy (1997–2016), which includes management, investment, legal, and supporting guidelines to address water pollution, air pollution, noise and vibrations, pollution from solid waste and night soil, pollution from hazardous materials, and pollution from hazardous waste. Environmental standards include those on water quality (2009), air quality and noise (2007), and soil quality (2004).

Overall, the Hazardous Substance Act of Thailand, which was promulgated in 1992, allows dealers to import only those that can be sold as parts if they are valuable as resources.

5.4. Waste Management

In terms of a general waste management strategy, Thailand created the *National Solid Waste Management Master Plan (2016–2021)* in May 2016, setting targets to properly manage municipal solid waste, industrial waste, and hazardous waste. Further plans were also created to increase the proper management of industrial waste and to reduce the amount of waste entering landfills, including the *Action Plan on Plastic Waste Management* and the Phase II of the *National Solid Waste Management Master Plan (2022–2027).*

In 2023, the Notification of Ministry of Industry Subject: Management of Waste or Unused Materials B.E. 2566 (2023) updated the regulation on waste management, which specifically listed ELV from different means of transport amongst all the categories of waste or unused materials. Furthermore, the following regulations stipulate general waste management in Thailand.

Enhancement and Conservation of National Environmental Quality Act B.E. 2535. The act regulates the environmental protection plan, standards, and monitoring of industrial and infectious waste. The owner of a facility, equipment, or instruments that discharge polluted air or other pollutants, or a wastewater treatment or waste disposal facility, must collect statistics and data and must submit a report on the results to a local official at least once per month. The local official must gather the reports received and send them to the pollution control official who has jurisdiction over that locality at least once per month.

Factory Act B.E. 2535. The Factory Act stipulates that the responsible minister has the power to issue ministerial regulations prescribing standards and methods of controlling the discharge of waste, pollutants, or anything affecting the environment as a result of factory operation. The regulations under the Factory Act stipulate the safe transport, containment, and storage sites of hazardous materials.

Hazardous Substances Act B.E. 2535. The act stipulates the rules and standards on importation/exportation, production, transport, use, and disposal of hazardous substances. A person appointed by the responsible minister for the execution of this act can enter into a place of business that is relevant to hazardous substances, place of production or storage of hazardous substances, or any other place or vehicle suspected be carrying hazardous substances to inspect the hazardous substances, container of the hazardous substances, books of accounts, documents, or other things relating to

hazardous substances; take hazardous substances or substances suspected to be hazardous as specimens for inspection; search for, detain, or seize hazardous substances, containers of hazardous substances, books of accounts, documents, or other relevant things if there are reasonable grounds to suspect that an offence under this act has been committed; and summon any person in writing to give a statement or to submit any document or thing for investigation. A person who fails to grant access to the appropriate facility to the competent official in the performance of his/her duties may face imprisonment up to 1 month or to a fine up to THB10,000.

Industrial Estate Authority of Thailand Act B.E. 2522. This act is in regard to industrial estates and the treatment methods of industrial waste and hazardous waste. A person appointed by the minister for the execution of this act can enter any place of an industrial entrepreneur, trader, or business entrepreneur that is beneficial to, or connected with, an industrial undertaking located in an industrial estate or to examine any document or object necessary. If the competent official plans to enter the place, the governor or a person entrusted by the governor will issue a written notification to the industrial entrepreneur, trader, or business entrepreneur not less than 24 hours in advance, provided that the governor or the person entrusted by the governor is of the opinion that it is urgent. Whoever fails to render facilities to the competent official may be liable to a fine up to THB5,000.

Notification of Ministry of Industry, Management of Waste, or Unused Materials B.E. 2566 (2023). This notification is published based on the Factory Act, classifies hazardous waste, and specifically lists ELV from different means of transport amongst all the categories of waste or unused materials. The following table lists the waste defined by the notification relating to ELV.

Table A2.18. Hazardous Waste List of the Notification on Management of Waste or Unused Materials, Thailand

Code	Type	Hazardous Wastes
1301	HA	Waste hydraulic oil
1302	HA	Waste engines, gears, and lubricating oil
1307	HA	Waste liquid fuel
1406	HA	Waste organic solvents, refrigerants, and foam/aerosol propellants
1601		End-of-life vehicles from different means of transport (including off- road machinery) and waste from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 1606, and 1608)
160103		End-of-life tires
160104	HM	End-of-life vehicles
160106		End-of-life vehicles, containing no liquids nor other hazardous components
160107	HA	Oil filters
160108	HM	Components containing mercury
160109	HA	Components containing polychlorinated biphenyls

Code	Type	Hazardous Wastes
160110	HA	Explosive components (e.g. airbags)
160111	HM	Brake pads containing asbestos
160112		Brake pads other than those mentioned in 160111
160113	HA	Brake fluid
160114	HM	Antifreeze fluid containing dangerous substances
160115		Antifreeze fluid other than those mentioned in 160114
160116		Tanks for liquefied gas
160117		Ferrous metal
160118		Non-ferrous metal
160119		Plastic
160120		Glass
160121	HM	Hazardous components other than those mentioned in 160107–160111 and 160113 and 160114
160122		Components not otherwise specified
160180	HA	Radiator coolant fluids containing dangerous substances such as glycol
160181		Radiator coolant fluids other than those mentioned in 160180
160199		Waste not otherwise specified
1606		Batteries and accumulators
160601	HA	Lead batteries
160602	HA	Nickel-cadmium batteries
160603	HA	Mercury-containing batteries
160604		Alkaline batteries (except 160603)
160605		Other batteries and accumulators
160606	HA	Separately collected electrolytes from batteries and accumulators
160696	HA	Nickel-metal hydride batteries
160697	HA	Lithium-ion batteries
160698	HA	Other batteries and accumulators containing hazardous substances
1608		Spent catalysts
160801		Spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium, or platinum (except 160807)
160802	HM	Spent catalysts containing dangerous transition metals (i.e. scandium, vanadium, manganese, cobalt, copper, yttrium, niobium, hafnium, tungsten, titanium, chromium, iron nickel, zinc, zirconium, molybdenum, and tantalum) or dangerous transition metal compounds
160803		Spent catalysts containing transition metals or transition metal compounds not otherwise specified

Code	Type	Hazardous Wastes
160804		Spent fluid catalytic cracking catalysts (except 160807)
160805	HM	Spent catalysts containing phosphoric acid
160806	HA	Spent liquids used as catalysts
160807	HM	Spent catalysts contaminated with dangerous substances

HA = hazardous waste – absolute entry, HM = hazardous waste – mirror entry, HS = harmonised system.
Note: Any waste whose six-digit code is marked with 'HA' (Hazardous waste – Absolute entry) or 'HM' (Hazardous waste – Mirror entry) is hazardous waste according to characteristics. However, the 'mirror entries' cover waste that has the potential to be hazardous or non-hazardous, depending on its actual composition and the concentrations of 'dangerous substances' within the waste. Therefore, for waste that is marked 'HM', analysis should be performed according to the criteria prescribed to demonstrate whether waste is hazardous according to this notification.
Source: MOI (2023).

The notification also settles the management method of waste as the responsibility of generators, which refers to the factory operators in accordance the Factory Act B.E. 2535 (1992). Initially, waste and unused materials must be clearly distinguished between hazardous and non-hazardous categories and stored separately. Containers used for storage must be inspected regularly to ensure that they are in safe working condition and properly labelled with details including the generator's name, type of waste, and containment dates. Both indoor and outdoor storage areas should be robust and stable, with appropriate containment systems to prevent leaks and spills, while being mindful of environmental factors like temperature and humidity that may cause hazardous reactions. Handling of waste within the factory must adhere to scientific principles dictated by the director-general to avoid environmental harm. Waste cannot be removed from the premises without an approved permit from the director-general. Before removal, detailed management plans must be notified as per established criteria. Waste transport requires the generator to ensure that vehicles are tracked and monitored according to the director-general's standards. Any mishandling, unauthorised disposal, or accidents must be rectified by the generator. An annual report on storage and handling compliance must be submitted to DIW electronically. Generators must ensure that processors handling the waste comply with the regulations, and in case of any failure, they must notify the authorities and apply for a permit to transfer the waste to another processor. Finally, any analysis needed for permit consideration must be conducted by accredited laboratories.

Ministerial Regulation Regarding Management of Toxic and Hazardous Waste from Communities B.E. 2563 (2020). Standards were established on household lightbulbs, batteries, spray cans, ink cartridges, and other waste electrical and electronic equipment for the management of toxic and hazardous waste.

5.5. Licences for Recyclers

Dismantling operators must acquire a licence (DIW Code 105 and 106) under the Notification of the Ministry of Industry No. 15 B.E. 2544 (2001). Under the regulation, they are required to introduce appropriate pollution prevention measures. Municipalities must

regularly monitor the status of their implementation.

The vehicle dismantling business in urban areas is not expected to expand because the centre of ELV generation is in rural areas. Vehicle dismantling is mainly conducted by small,
low-technology, dismantling operations with low yield and capacity. Environmental measures such as the prohibition on illegal dumping of waste and collection of CFC are insufficient. The occupational health of ELV recyclers involved in the dismantling process and downstream recycling is also a challenge.

Enhancement and Conservation of National Environmental Quality Act B.E. 2535. This act notes that any person who renders services for wastewater treatment or waste disposal without a licence will be punished by imprisonment up to 1 year, a fine up to THB100,000, or both.

Notification of Ministry of Industry, Management of Waste or Unused Materials B.E. 2566 (2023). A waste processor, handling or managing any waste or unused materials in a factory and excluding those that only handle non-hazardous waste or unused materials, must receive approval by the DIW director-general.

5.6. Recycling Facilities

Thailand's Association for Used Cars promotes cooperation amongst used car dealers by improving their marketing potential and standard of products and services. Moreover, relevant legislation to recycling facilities includes the following.

Enhancement and Conservation of National Environmental Quality Act B.E. 2535. This act regulates that environmental impact assessments must occur for industrial waste treatment facilities. The owner of a facility that discharges polluted air or other pollutants, wastewater treatment facility, or waste disposal facility must collect data and submit a report to a local official at least once per month.

Notification of Ministry of Industry, Management of Waste, or Unused Materials B.E. 2566 (2023). Recycling facilities are required to follow stringent guidelines for waste management. When receiving unused materials, waste processors must perform inspections using random sampling methods to verify essential characteristics such as colour, specific gravity, and pH value. A report along with management documentation and any non-compliant materials must be made promptly. The facilities must clearly separate and store hazardous raw materials from non-hazardous ones, inspect containers for safety, and ensure proper labelling. Storage areas need to be well maintained, with clear signage, and should be suitably equipped to handle leaks or spills. Both indoor and outdoor storage must be robust, stable, and mindful of environmental factors like temperature and humidity that can cause hazardous reactions.

Recycling facilities must process non-hazardous raw materials within 60 days, and hazardous ones within 30 days, notifying the generator, who takes the responsibility to report to the director-general of DIW if extensions are needed. Additionally, recycling facilities need to have accident prevention and emergency response plans for incidents such as leaks, fires, or explosions. Monthly management reports on raw materials and products must be submitted electronically to the Ministry of Industry's central data reporting system by the 15th of each month.

6. Viet Nam

6.1. Vehicle Registration

Circular No. 24/2023/TT-BCA was issued by the Ministry of Public Security in 2023; vehicle registration is regulated by this regulation. Pursuant to Article 6 of Circular No. 21/2010/TT-BGTVT, the useful life of renovated and converted cars is calculated from the year of automobile manufacture before conversion. The draft road law proposes that a passenger car has a service life of no more than 20 years. Accordingly, the draft proposes that the service life for cargo cars (i.e. trucks) cannot exceed 25 years, and that of cars carrying 10 or more people (including the driver) cannot exceed 20 years.

Registration. New vehicle registrations must occur within 10 days of purchase. The owner obtains a licence plate and registration certificate with the owner's name, address, vehicle identification number, and other details. Any vehicle, purchased or imported, is required by law to be registered at the designated local police traffic office. All required documentation, including the certificate of vehicle inspection; vehicle registration declaration; proof of insurance; and owner's valid passport, visa, and/or work permit is required for registration. Registration fee ranges from 12% to 15% of the purchase price. From 2023, procedures for initial vehicle registration are carried out according to the provisions of Article 12 of Circular No. 24/2023/TT-BCA, and No.24/2023/TT-BCA and No.10/2022/ND-CP outline the EV registration procedure and necessary fee (i.e. 0% for 3 years).

Transfer of registration. According to Circular No. 24/2023/TT-BCA, within 30 days from the date of carrying out procedures for vehicle title transfer, a vehicle owner must carry out procedures for revocation; within the aforesaid duration, if a vehicle owner fails to carry out procedures for revocation or to transfer the vehicle registration certificate and licence plate to the transferee, before processing the procedures, a vehicle registration authority will issue a decision to impose administrative penalties on the vehicle owner.

Re-registration. Circular No. 24/2023/TT-BCA, Article 16 requests that a vehicle registration certificate and licence plate be replaced if a vehicle is modified; repainted; wants to change the licence plate with a white background, black letters, and numbers to one with a yellow background, black letters, and numbers or vice versa; needs an extension of the certificate of vehicle registration; changes the vehicle owner; finds that the certificate of vehicle registration is blurry, torn, or lost; finds that the licence plate is blurry, broken, or lost; or necessitates that the old certificate of vehicle registration and licence plate be replaced with a new certificate of vehicle registration and licence plate.

Deregistration. Revocation of a registration is necessary in case a vehicle becomes out of order, unusable, and damaged as stipulated by various laws.

Inspection. Previously Circular No. 16/2021 requested inspections on new vehicles. However, from 2023, the government changed that policy. Newly acquired vehicles are no longer required to have inspections for road use (Table A2.19).

Table A2.19. Mandatory Mechanic Examinations during Registration, Viet Nam

No.	Type of Transport	Cycle (month)	
		First	Periodic
1. All kinds of vehicles carrying people with up to 9 seats and are not conducting transport business			
1.1	Production time up to 7 years	36	24
1.2	Production time over 7 years to 20 years		12
1.3	Production time over 20 years		6
2. All kinds of vehicles carrying people with up to 9 seats and are conducting transport business			
2.1	Production time up to 5 years	24	12
2.2	Production time over 5 years		6
2.3	There are renovations.	12	6
3. All kinds of vehicles carrying people with up to 9 seats			
3.1	Production time up to 5 years	24	12
3.2	Production time over 5 years		6
3.3	There are renovations.	12	6
4. Trucks of all kinds, specialised vehicles, tractors, trailers, semi-trailers			
4.1	Trucks of all kinds, specialised vehicles, and tractors with a production period of up to 7 years; trailers and semi-trailers with a production period of up to 12 years.	24	12
4.2	Trucks of all kinds, specialised vehicles, and tractors with a production period of more than 7 years; trailers and semi-trailers with a production period of more than 12 years.		06
4.3	There are renovations.	12	06
5	All kinds of vehicles carrying people with up to 9 seats, which have been manufactured for 15 years or more (including vehicles with over 9 seats that have been converted into vehicles with under 9 seats).		03

Note: The number of seats on vehicles includes the driver seat.
Source: MPS (2023).

Insurance. All vehicles driven in Viet Nam are required to be insured. Having a civil liability insurance policy is compulsory. Uninsured drivers may be fined and are at risk of having their vehicles confiscated. The process of insurance is the same for Vietnamese and foreign-born residents. To obtain insurance, applicants need to present their personal identification and other valid documents such as passport, visa, and/or identity card. Discounts are available for drivers who have had no accidents or claims in Viet Nam during the previous year.

6.2. End-of-life Vehicles

The lifespan of a vehicle is regulated by Decree No. 95/2009/ND-CP (Article 4) and Circular No. 21/2010/TT/BGTVT (Article 6 and Article 7). A bus that exceeds its service life, and is converted to a truck, and a truck that is converted to a special motor vehicle, will have a service life that cannot exceed 25 years. A bus with at least 10 seats (including the driver's seat), special passenger vehicle that is converted to a bus with less than 9 seats (including the driver's seat), and bus with up to 9 seats (including the driver's seat) that is converted into a truck will have a service life that cannot exceed 20 years.

For passenger cars, the lifespan is limited to 20 years. According to Circular No. 21/2010/TT-BGTVT, the life of a four-seat family car is based on specific technical criteria. The vehicle usage time is calculated from the year of manufacture and determined through factors such as the vehicle identification number, chassis number, technical documents from the manufacturer, information on the manufacturer, and production and archived records such as quality certificates and factory quality inspection sheets. However, large numbers of vehicles exceeding their service lives are still on the road in Viet Nam. According to the field research by the study team, it is a popular opinion that the life of vehicles is vague and not well understood by users.

Other regulations on ELV include the following.

Decision No. 16-2015 QD TTg. Issued in August 2013, the decision requires manufacturers and importers to take back their sold products. This regulation towards vehicles was planned to be implemented in 2018.

Decree No. 08/2022/ND-CP, revising Decision No. 16-2015 QD TTg. Since 2022, producers and importers of vehicles must fulfil their responsibility for recycling products and packaging that they produce/import from 1 January 2027. The Ministry of Natural Resources and Environment (MONRE) will submit regulations on the disposal of vehicles to the Prime Minister for promulgation before 1 January 2025.

Decree No. 08/2022/ND-CP. This describes mandatory recycling rates and specifications. The mandatory recycling rate is the ratio of the minimum weight of a product or packaging that must be recycled according to mandatory recycling specifications to the total weight of a product or packaging manufactured, put on the market, and imported in the year in which the responsibility is fulfilled. The mandatory recycling rate of each type of product or packaging is determined based on its life cycle, disposal rate and collection rate, national recycling target, environmental protection requirements, and socio-economic conditions. The mandatory recycling rate is adjusted every 3 years to meet the national recycling target and environmental protection requirements.

Decree No. 08/2022/ND-CP. This describes methods for fulfilling recycling responsibility in Article 79. Producers and importers must select a method for fulfilling their recycling responsibility.

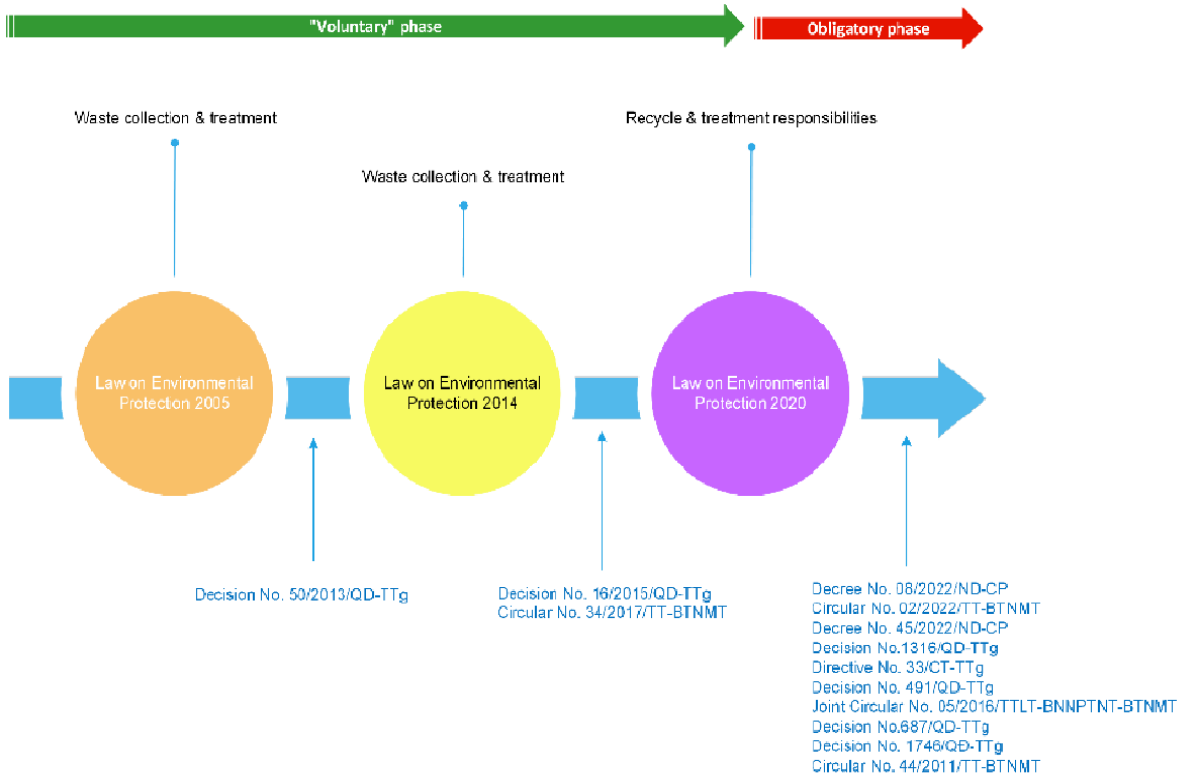
Decree No. 08/2022/ND-CP. This describes registration of recycling plans and reporting of recycling results. Every producer and importer must register their annual recycling plan and report recycling results of the previous year to MONRE before 31 March every year. A recycling plan is registered according to the weight of products and packaging manufactured and put on the market in the immediate previous year. The producer/importer or authorised party assumes legal responsibility for the accuracy of

the recycling plan registration information and results reported. If the recycling plan or recycling result report is unsatisfactory, MONRE will notify the producer/importer or authorised party to redo the plan or report within 30 working days from the receipt of the notification.

6.3. Recycling

MONRE updated Decree No. 08/2022/ND-CP in October 2023, shifting EPR to a mandatory framework from January 2024; ELV are subject to this framework from 2027.

Figure A2.9. Process of EPR Regulations in Viet Nam



EPR = extended producer responsibility.
Source: Authors.

Decree No. 08/2022/ND-CP describes recycling for road vehicles as dismantling, sorting, and recovering by type of material including metal and plastic. According to Nguyen (2020), every ELV is required to be taken back and treated as waste and hazardous waste. Article 70 of Decree No. 08/2022/ND-CP states that any organisation or individual that generates hazardous waste must treat hazardous waste in compliance with environmental protection requirements as prescribed; conform to decisions regarding environment impact assessment appraisal results, environmental licences, or component environmental licences; and not construct new incinerators and landfills to treat hazardous waste, except where solid waste management contents specified in relevant planning are conformed to.

6.4. Waste Management

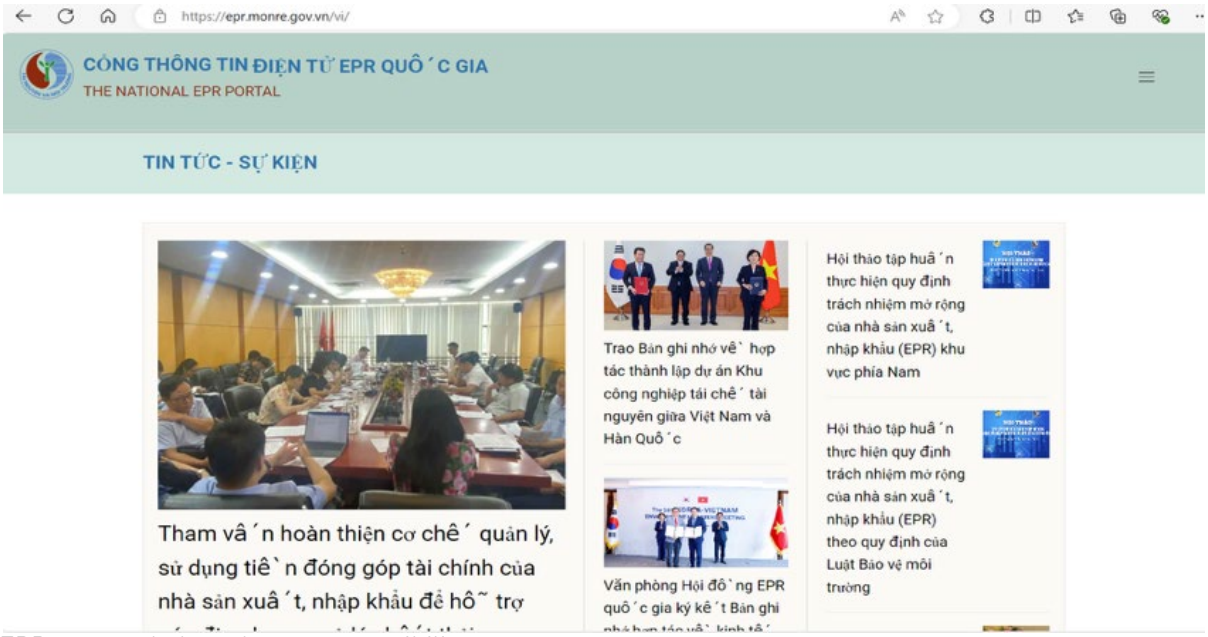
Circular No. 12/2011/TT-BTNMT stipulates that ELV are on the hazardous waste list. Recycling and treatment facilities thus must possess hazardous waste management permits. Treatment of waste oil and batteries – but not tires – must have hazardous waste management permits.

Under Circular No. 12/2011/TT-BTNMT, the Vietnam Environment Administration can grant and revoke hazardous waste management licences to entities operating in areas covering two or more provinces or centrally run cities. Provincial people's committees or natural resources and environment departments empowered by provincial people's committees can grant and revoke hazardous waste management licences to entities operating in areas within their respective provinces.

MONRE requires e-waste generators to transfer waste to licensed collectors, transporters, and treatment facility operators. Those generators, collectors, and treatment operators must report to MONRE every 6 months regarding the control situation of their facility.

As explained previously, Decree No. 08/2022/ND-CP revising Decision No.16-2015 QD TTg implemented new regulations on EPR. In July 2027, MONRE announced the official operation of a national portal for EPR, supporting manufacturers and importers in registering, declaring, and reporting their activities. Via the EPR portal, those subject to EPR obligations in recycling their products and packaging and in handling waste are now able to register, declare, and report their compliance with product-packaging recycling and waste management responsibilities online instead of submitting paper documents to the ministry. Furthermore, they can access the website to be updated on legal regulations and to receive legal advice (Figure A2.10).

Figure A2.10. EPR Website, Viet Nam



EPR = extended producer responsibility.
Source: EPR Office, https://epr.monre.gov.vn/

6.5. Licences for Recyclers

Currently there are no specific licences granted to ELV recyclers. However, every hazardous waste treatment service provider must obtain an environmental licence. Additionally, MONRE has published a list of authorised organisations for EPR recycling of products and packaging in accordance with the implementation of mandatory recycling activities for packages, batteries, lubricants, and tires (Table A2.20). Therefore, updated regulations for ELV under an EPR framework are assumed to be issued, including related licences and authorised organisations for ELV recycling activities.

Table A2.20. Mandatory Recycling Ratio under EPR Scheme

Product	Starting Date	Recycling Ratio
Packages containing foodstuffs, cosmetics, medicines, fertilizers, animal feed, veterinary drugs, detergents, and cement	1 January 2024	10.0–22.0%
Rechargeable batteries		8.0–12.0%
Machine oil		15.0%
Tires and tubes		5.0%
Electrical and electronic equipment	1 January 2025	3.0–15.0%
Transport (e.g. bicycles or cars)	1 January 2026	0.5–1.0%

EPR = extended producer responsibility.
Source: PWC (2024).

For hazardous waste treatment, every hazardous waste treatment service provider must obtain an environmental licence that covers hazardous waste treatment services as prescribed or a component environmental licence to treat hazardous waste. Decree No. 08/2022/ND-CP states that MONRE must promulgate technical regulations and technical regulations on the treatment, use, and reuse of hazardous waste. Where a technical regulation or technical guidance is yet to be promulgated, the standard of a developed country will apply.

6.6. Recycling Facilities

Article 62 of Decree No. 08/2022/ND-CP describes the rights and responsibilities of solid waste treatment facilities. Every facility must comply with all environmental protection requirements as prescribed by law; fulfil responsibilities of hazardous waste generators as prescribed for hazardous waste from solid waste or solid waste treatment facilities; and operate solid waste treatment facilities in accordance with environmental technical regulations and ensure that solid waste received under signed contracts is completely treated.

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