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Recent Recycling Procedures for End-of-Life Vehicles (ELV) Metals in Malaysia

(Prosedur Terkini bagi Kitar Semula Logam daripada Kenderaan Akhir Hayat (ELV) di Malaysia)

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ABSTRACT

In Malaysia, a large number of abandoned End-of-Life Vehicles (ELV) problems pose a concern due to a lack of adequate regulation and action, while in Japan, a recycling system has been built and legislation controlling ELV recycling has been approved. The purpose of this article was to identify and investigate the current ELV recycling procedures in Malaysia, with a focus on metal recovery. This research also attempted to identify and review the ELV metal recycling procedures in Japan, as well as to compare and contrast them with Malaysian practices. A case study was conducted to investigate the ELV metal recycling procedure used by recyclers in Malaysia, thereby producing an ELV recycling framework. Publications on ELV metal recycling from Malaysia, and Japan will assist in determining, by identifying the ELV metal recycling technique used, the disparity between these two countries. Japan's ELV recycling has long been recognized for its importance in secondary metal recovery and reducing ELV waste to the environment. The recovery of secondary resources, such as ferrous metals, non-ferrous metals, and precious metals, from the recycling of ELVs reduces reliance on primary resources. It has been proven that ELV recycling aids in the prevention and control of ELV development around the world.

Keywords: End-of-Life Vehicles (ELV); ELV recycling; metals recycling procedures

ABSTRAK

Angka bilangan Kenderaan Akhir Hayat (ELV) yang terbiar di Malaysia kian meningkat telah menimbulkan kebimbangan kerana tiada penguatkuasaan undang-undang dan tindakan sewajarnya diambil, manakala di Jepun, sistem kitar semula telah dibangunkan dan undang-undang yang mengawal selia kitar semula ELV telah diluluskan. Artikel ini ditulis bertujuan untuk mengenal pasti dan menyelidik prosedur terkini kitar semula ELV di Malaysia, dengan memberi tumpuan kepada pemulihan logam. Penyelidikan ini juga dilaksanakan bagi mengenal pasti dan mengkaji semula prosedur kitar semula logam ELV di Jepun, serta membandingkan dan membezakannya dengan amalan di Malaysia. Satu kajian kes telah dijalankan untuk menyiasat prosedur kitar semula logam ELV yang digunakan oleh pengitar semula lalu menghasilkan rangka kerja kitar semula ELV di Malaysia. Penerbitan mengenai kitar semula logam ELV dari Malaysia dan Jepun dapat membantu dalam menentukan dan mengenal pasti teknik kitar semula logam ELV yang digunakan serta perbezaan amalan antara kedua-dua negara ini. Kitar semula ELV di Jepun telah lama diiktiraf kerana kepentingannya dalam pemulihan logam sekunder dan pengurangan pencemaran sisa ELV terhadap alam sekitar. Pemulihan sumber sekunder, seperti logam ferus, logam bukan

ferus dan logam berharga, daripada prosedur kitar semula ELV mampu mengurangkan pergantungan kepada sumber utama. Terbukti bahawa kitar semula ELV dapat membantu dalam pencegahan dan pengawalan pertumbuhan ELV di seluruh dunia.

Kata kunci: Kenderaan Akhir Hayat (ELV); kitar semula ELV; prosedur kitar semula logam

INTRODUCTION

ELV is a vehicle that is not in use. Based on either the vehicle's age or the fact that it cannot be used due to severe damage, it is thought to fall under the ELV category (Ahmad Nawawi et al. 2020). ELVs are divided into two types: natural ELVs and retired automobiles. Vehicles that have failed throughout the inspection procedure are classified as natural ELVs, while retired cars are also referred to as unusable vehicles or premature ELVs due to physical failures caused by vandalism, fire, and accidents (Raja Mamat et al. 2016). End-of-life vehicles (ELVs) are automobiles that have reached the end of their useful lives and are no longer fit for use, resulting in millions of metric tonnes of waste (Junior et al. 2016). In reality, ELVs are one of the most common waste streams that are mishandled, resulting in contamination (Wong et al. 2018). Thus, this can be overcome by practicing ELV recycling as implemented by the Japanese community.

The definition of material recycling (or recovery) is the use of waste for other uses by processing (such as separation, washing, melting, transformation, etc.), but the majority of waste fractions must be used as materials for other purposes (Akram Khan et al. 2021). Meanwhile, the fundamental concept of recycling scrap cars is to first turn them into spare parts, and if that is not possible, to recycle the cars themselves (Cumbul Altay et al. 2011). Two steps make up the ELV recycling process: disassembly and shredding. To begin with, the product can be reconditioned or reused because the disassembly process may involve a component with a higher recycle value. During the shredding procedure, an ELV is compressed and fed into a drum, where it is torn apart by several revolving hammers until the pieces are tiny enough to fall out of an output grid. Dismantling and shredding take place during the in-process phase of the present ELV recycling process, and material recycling and energy recovery take place during the post-process phase. Physical labor is frequently required during dismantling to gather more expensive parts for resale or reconditioning by remanufacturers. The ELV will be shipped to a shredding mill to be divided into smaller, more manageable pieces for the shredding process, along with seriously damaged and complicated components (Gołębiewski et al. 2013).

The importance of reusing, recycling, and recovering valuable resources from outmoded items and trash has been emphasized in the 2006 National Environmental Policy. The following benefits of recycling metals have been highlighted by Hagelüken et al. (2016): (i) adopting core raw materials in its alternative; (ii) production of secondary raw materials has less of an impact on the environment and CO2 than that of primary raw materials; (iii) lowering reliance on imported goods and ensuring a steady supply of valued goods, some of which are essential goods; (iv) preventing the landfilling and burning of metals, which not only wastes important raw materials but also harms the environment; and (v) supporting economic activity at various stages of the value chain for metal recycling.

ELVs can be recycled for more than 80% of their weight, and the recycling rate of ELVs has always been high when compared to other consumer goods (Petronijević et al. 2020). Table 1 shows the composition of an ELV. Ferrous and non-ferrous metals make up 72–76% of the weight of the car. Plastics, tires, glass, batteries, electronics, operating fluids, fabrics, and rubber make up the remaining 24–28% of the weight of the car. Metals, both ferrous and nonferrous, have a high recycling rate and are easily traded on the secondary market (Venkatesan & Annamalai 2017).

TABLE 1. Composition of an ELV

Material	% by weight
Ferrous metal	65.4 – 71.0
Non-ferrous metals	7.0 – 10.0
Plastics	7.0 – 9.3
Rubber (including tires)	4.0 – 5.6
Glass	2.9 – 3.0
Fluids	0.9 – 6.0
Battery	1.0 – 1.1
Process polymers	1.0 – 1.1
Electrical/electronics	0.4 – 1.0
Other	1.0 – 5.9

Source: Gerrard and Kandlikar (2007); Mat Saman and Blount (2006); Vermeulen et al. (2011)

As the automotive sector grows, its environmental impact grows as well. To preserve the environment and decrease human impact on nature, a comprehensive waste management regulation is required (Azmi et al. 2013). Hence, this article aims to identify and investigate the current ELV recycling practices in Malaysia, with a particular emphasis on metal recovery. This study also aims to identify, assess, and analyze the ELV metal recycling

procedures in Japan, along with comparing and contrasting Malaysian practices with those in Japan.

METHODOLOGY

With the aid of Malaysia Automotive Robotics & IoT Institute (MARii) and web research, a list of recyclers has been compiled for the case study. 8 of these businesses responded positively when they were contacted about participating. They preferred that the interview be conducted through a site visit, an online meeting, and phone calls. The questions covered a variety of subjects, such as where ELV metal parts and components came from, the types of metal used, the general steps involved in recycling ELV metal parts and components, the results of recycling ELV metal parts and components, and the buyer of recycled metal parts and components. The interview's findings were to be included in a framework for recycling ELV metals. However, to recognize and understand the distinctions between Malaysian practices and the recycling methods employed in Japan, publications are required. A comparison of the 10 article papers was evaluated, and were to be covered later. We will assess secondary data in addition to qualitative information through interviews and paper reviews. The results will be used to create a framework for the ELV metal recycling process, which will help recyclers in Malaysia comprehend the present ELV metal recycling process.

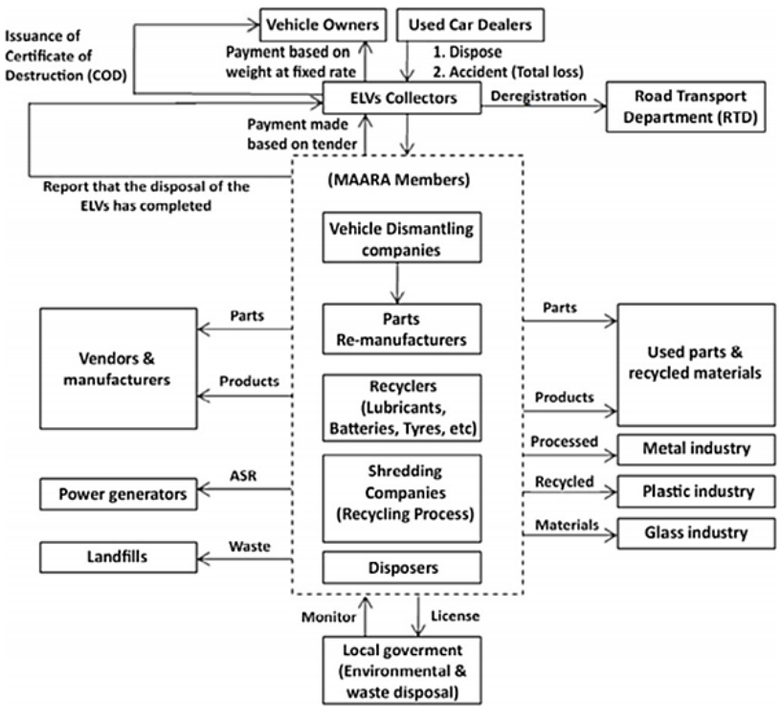

FIGURE 1. Ideal Malaysian ELV processing flow
Source: Malaysia Automotive Institute (2017)

DISCUSSION

ELV RECYCLING IN MALAYSIA

A few local entities have published research, methods, and tactics for managing and recovering ELVs. MARii's proposed a Malaysian ELV processing flow as in Figure 1. The method is very similar to that of other nations, where the deregistration procedure must be completed before the ELVs are dismantled. A Certificate of Destruction must be given to vehicle owners by ELV collectors, and payment would be made based on a defined or predetermined scrap value. A local government entity called the Department of Environment would be in charge of overseeing the entire process, starting with disassembly and ending with disposal. Parties to carry out the dismantling of ELVs would include recyclers, disposers, parts producers, shredding businesses, and vehicle-dismantling businesses. The current shredding and sorting plants have been added to the list of Authorized Treatment Facilities (ATFs).

Malaysia's ATFs must obtain a waste management license from the relevant environmental agency, adhere to standards, remove all hazardous materials and liquids (a process known as "depollution"), recycle the parts properly, and store and dispose of them properly (Kojima 2018).

The Automotive Shredder Residue (ASR) incinerators receive ASRs. Usable components would be managed by remanufacturers and suppliers, and other parts that need to be processed and recycled would be handled by the appropriate industries responsible for new products (Malaysia Automotive Robotics & IoT Institute 2017). This is the best framework that has been developed for Malaysian ELV recycling. Later, we will examine the actual situation and how recyclers have responded to it.

COMPANY A

The approach used by Company A, a local authority, to get rid of abandoned cars by auctioning off the scrap metal pieces to dealers has been lengthy and has caused the municipality serious storage problems. Company A became an ELV supplier by taking part in transporting abandoned vehicles to an Authorized Automotive Treatment Facilities (AATF), where scheduled waste such as batteries, engine oil, air-conditioning gases, coolants, and other parts are separated for repurposing, recycling, or recovery.

COMPANY B

Company B is an AATF. ELVs marked SW422, can be acquired via an insurance company or local authority. Depollution is performed on coolant, hydraulic oil, brake fluid, transmission fluid, gearbox fluid, and other potentially dangerous fluids. All metal parts and components, including the engine, gearbox, catalytic converter, chassis, and tyre rims, would be disassembled. The ferrous and non-ferrous metals trading company, which is a licensed and certified agent, would then sell the parts and components to the dealer once they are ready. After melting the metal, the smelter would create steel bars, wire rods, and flat bars, all of which happen to be frequently used in the construction sector.

COMPANY C & D

Company C (a subsidiary of Company E) has created its own platform for disassembling and disposing of stranded ELVs. It has been outfitted with standard dismantling tools and equipment and is backed by highly skilled specialists. Company E would tow ELVs and send them to Company C's deck. Company C serves as the deck for ELV's acquisition and dismantling. As part of a collaboration with Company D, a local authority firm, Company E was able to gather (acquire) 30–40 abandoned cars and had then transferred them to the Company C site.

COMPANY E

Company E would then perform the function of a dismantler. During the depollution procedure, hazardous fluids such as engine oil and leftover gasoline would be removed. Then, the metal components would be disassembled. The chassis would be kept apart from the other parts of the system. Traders (agents) of spare parts would purchase used metal components in good condition, and would then sell those parts to their retailers (dealers). Car chassis and used metal components in poor condition would be sold as scrap metal by traders (agents) who specialize in collecting, sub-processing, and marketing scrap ferrous and non-ferrous metal to smelters (dealers) who operate in the construction business. The smelter would melt the chassis and other damaged metal components to create steel bars, wire rods, and flat bars, all of which are widely used in the construction industry.

COMPANY F

Company F recycles and trades used automobile parts. Company F purchases end-of-life vehicle (ELV) metal parts from both foreign and domestic suppliers. While Malaysians voluntarily donate their vehicles for scrap and spare parts, foreign engines from the UK and Japan are used as spare parts while the metal and engine parts would be reused and sold to the customer. Car bodies that are displayed in good condition would be half-cut and would be available for purchase. Engine parts and metal components that are damaged would be recycled and turned into scrap metal. Each type of steel would be purchased by a different smelter, depending on the offer and pricing. Steel bars, wire rods, and flat bars would be produced by melting metals in smelters as building support materials.

COMPANY G & H

Company G handles a few types of scrap metal, while Company H specializes in buying and towing abandoned cars. The owner of the car would willingly submit (sell) these ELVs because the vehicle would be unable to function as previously. Both Company G and Company H would disassemble useable components and compress the ELV before selling these to spare-part merchants and smelters, respectively.

In conclusion, ELV recycling in Malaysia appears to be similar in terms of managing ferrous and non-ferrous metals from the entire ELV, with these companies beginning with depollution, dismantlement, and metal segregation before selling them to the smelters in Malaysia. Then, pure metals would be removed and used to create building support materials, mostly for the construction industry. Hence, Figure 2 below concludes the current ELV recycling in Malaysia.

Although some ELVs would be disposed of due to their state, it has been anticipated that this approach could recycle and recover as much metal as possible. This business organization has been in operation for 30 to 40 years and is still in operation now, but with stronger oversight, modern equipment and technologies, as well as better surveillance. However, due to ineffective rules and low levels of education, awareness, and exposure provided for ELV recycling in Malaysia, a significant amount of ELV is still not being recycled. Researchers estimate that by 2020, there will be more than 100 million ELVs in the world (Tian & Chen 2014).

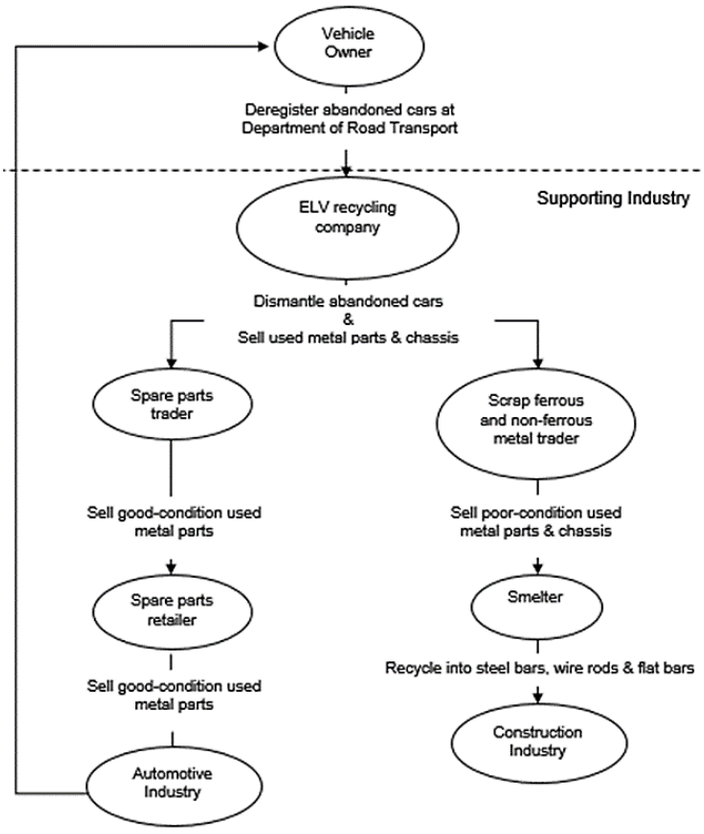

FIGURE 2. Current ELV Metal Recycling in Malaysia

Recently, the National Automotive Policy 2020 (NAP 2020) contained recommendations for enhancing the standard of component recycling and reuse to the current Malaysia Standard: MS 2697:2018 Motor Vehicle Aftermarket: Repair, Reuse, Recycle, and Remanufacture (4R) for Parts and Components and MS 2696:2018 Motor Vehicle Aftermarket: Service and Spare Parts (2S) (Ministry of International Trade and Industry 2020). NAP is our new hope and solution for ELV problems in Malaysia. Therefore, to ensure that Malaysia's ELV recycling rate increases and that more secondary metals are recycled back rather than squandered and kept from harming the Earth, we need to look back at Japan's ELV recycling system for future guidance. A proper regulation for handling ELVs is crucial, as the management of ELVs is heavily dependent on a country's legislation and policy, as expressed in the European Commission's directive, Japan's law on ELV recycling, and China's technical strategy for the recovery and usage of vehicle goods (Abu Kassim et al. 2020).

ELV RECYCLING IN JAPAN

The Japan ELV recycling model has been used as a benchmark since it has undergone extensive development

and testing since 2005, with ongoing improvements. The setup for the material, information, and financial flows involved in managing ELVs is complete in the model. Thus, this comparison is necessary. Hiratsuka et al. (2013) addressed the background and features of how the ELV recycling system was set up in Japan.

The parties liable for the costs of recycling are the users (Ahmad Nawawi et al. 2020). If the ELV contains fluorocarbons, the collector operator provides it to a fluorocarbon recovery facility; if not, the dismantling operator receives it. While removing some components, such as batteries, the dismantling operator gathers the valuable materials and parts for reuse and recycling. The disassembled vehicle is then destroyed by the shredding operator, who also collects valuable scrap metal and delivers it to the importer or manufacturer. If not, vehicle dismantlers and shredders transfer their products to scrapyards, where they are purchased in their entirety. It is legal for vehicle dismantlers and shredders to deliver whole, dismantled automobiles to scrapyards; these vehicles are subsequently used as iron and steel raw materials by being placed in electric arc and blast furnaces or exported as raw materials. Used and refurbished components are offered for sale on the domestic market in Japan. Through the information system, stock and order information are transferred. Figure 3 shows the material, informational, and financial flows involved in the recycling of ELVs in Japan.

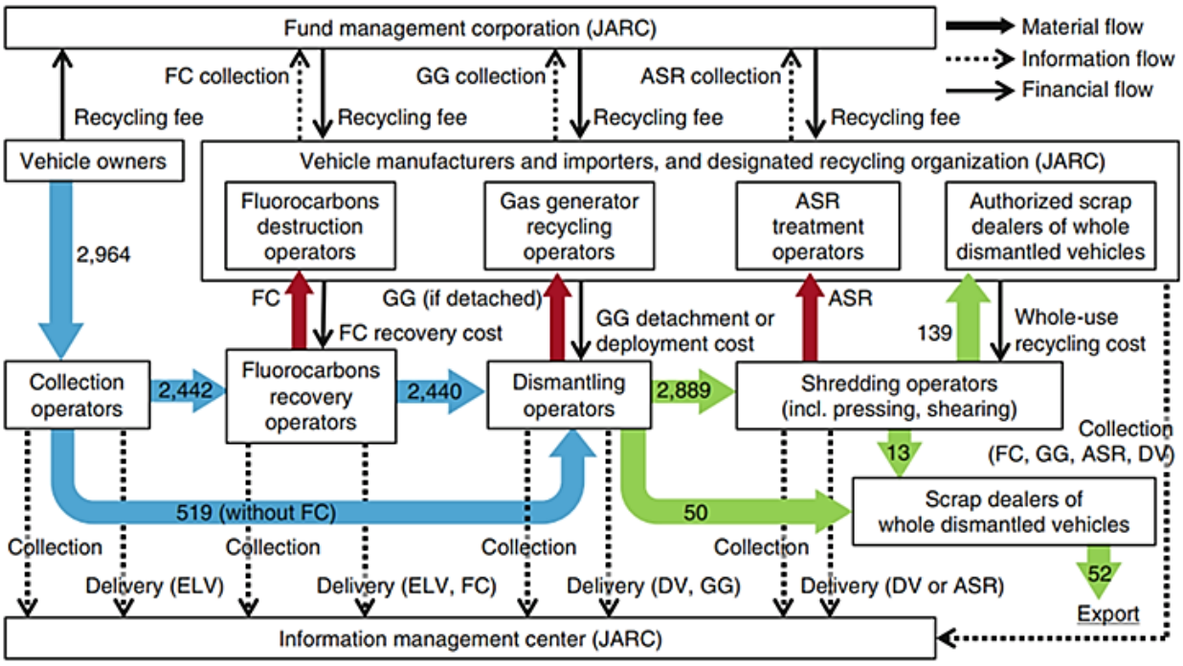

FIGURE 3. Japan ELV processing flow
Source: Hiratsuka et al. (2013)

The Miyagi Automobile Car Recycling Centre's dismantling process contains several significant steps. First, the general ELV recycling process comprises draining the battery, disconnecting the bomb, air backing it to pieces, detaching the tire, and draining or removing the old oil and fluid. Furthermore, aluminium and copper are extracted by hand or with the aid of heavy machinery and then placed in a press machine, where they are compacted into a mass (Che et al. 2011). As a result, practically all components and materials of ELVs other than ASR are reused and recycled, resulting in roughly 99% of ELVs being reused, repurposed, and recovered by weight. ASR is processed in one of three ways by ASR treatment operators: (a) recycling and energy recovery, which includes metal recycling, recycling and energy recovery by gasification, and recycling and energy recovery in cement kilns; (b) incineration without energy recovery; and (c) direct landfill (Hiratsuka et al. 2013).

Whenever it comes to depollution, dismantling, segregating metals, and selling them to scrap dealers both domestically and abroad, Japan's ELV recycling appears to be similar to Malaysia's. In Japan, each metal is recovered. This could be noticeable because they have been fully equipped with recycling facilities and educational resources. Additionally, the system has received remarkable attention and funding.

COMPARISON ON BOTH ELV RECYCLING APPROACH

Malaysia now recycles ELV like Japan. In contrast to Malaysia, ELV recycling has been well established in Japan. Since 2005, when Japan's Law for the Recycling of End-of-Life Vehicles had been amended, numerous improvements have since been implemented. On the other hand, Malaysia still lacks a suitable mechanism for recycling ELVs, though one has existed for the past ten years to meet market demand. It has been influenced by Malaysia's import of partially assembled automobiles and auto components from Japan as a result of Malaysia's ELV recycling programme.

JARC, the Japan Automobile Recycling Promotion Centre, has been in charge of handling ELV in Japan from the start. They are involved with the material, data and monetary flows of recycling ELVs. In Japan, the collection operator will send the ELV to a CFC recovery operator for CFC elimination before sending it to a dismantling operator, where valuable components and materials are gathered for recycling and reuse. The vehicle is then destroyed by the shredding operator, and the scrap metal is given to the importer or manufacturer. If a vehicle is not shredded, scrapyards receive it in its entirety. Dealers at scrapyards transform the disassembled vehicle into basic materials. To extract the pure raw metals, ASR is burned in an incinerator. Iron and steel are manufactured using raw materials, or raw materials are exported. ELVs are recycled.

While the government organizations in Malaysia, including the Ministry of Transport (MOT), the Department of Environment (DOE), the Malaysia Automotive & Robotics Institute (MARii), the Malaysia Automotive Recyclers Association (MAARA), and Malaysia Used Vehicle Autoparts Traders Association (MUVATA), are collaborating closely to make ELV recycling a reality in the country, the National Automotive Policy (NAP), Authorized Automotive Treatment Facility (AATF), 4R2S Malaysia Standard (MS 2697:2018 & MS 2696:2018), and ELV Scheduled Waste (SW422) treatment are only a few of the cooperative activities that have been implemented by each organization. Meanwhile, the ELV will be collected by the AATF in Malaysia. The AATF operator will begin with depollution procedures in which hazardous liquids are dumped and appropriately stored. This liquid will be sold to a designated disposal facility. The operator of AATF will remove metal components from the car chassis. Useful parts will be purchased and sold by the spare parts trader so that they can be used by the spare parts merchant. Chassis and unusable components will be sold by scrap dealers to smelters, who will melt the metals in a furnace. The metals will become pure raw metals and will then undergo tempering to become steel bars, wire rods, and flat bars for the building industry. Metals in ELV are recovered.

The ultimate goal shared by Malaysia and Japan is to recycle as much metal as possible for the building or automotive industries, which has been a success. Recycling of ELVs is quite methodical, particularly in Japan, which produces higher ELV recycling rates than Malaysia. In Malaysia, the execution of recycling of ELVs is dependent on the recycler adhering to the applicable environmental standards and being able to support themselves, which results in a lower ELV recycling percentage due to many factors. Both countries can spread the foundations of recycling and prevent the waste of metals.

Recycling of ELVs is widely recognized as being necessary for reducing the environmental impact of ELV trash. By recovering secondary resources from the recycling of ELVs, such as ferrous metals, non-ferrous metals and precious metals, it is possible to rely less on primary resources. This encourages the efficient use and conservation of resources. In certain industrialized countries, regulations governing the recycling of ELVs have been passed, but not in developing countries. Developed countries with sizable domestic auto markets make up the majority of countries currently attempting to improve ELV recycling practices. However, there are no rules in place to address the issue, and ELVs are not adequately managed in Malaysia. The annual increase in the number of manufactured and registered cars indicates that ELVs are becoming increasingly common. Inadequate management of ELVs has a significant detrimental influence on Malaysia's environment and social life, in addition to leaving ELVs in parking lots in residential communities and business buildings. This involves extreme pollution of the water, air, and soil (Raja Mamat et al. 2016).

Eight countries (Kenya, Cameroon, Egypt, Malaysia, Mexico, India, South Africa, and Nigeria) have shared weaknesses in ELV collection, waste regulatory framework, technological capacity, environmental impact and pollution, ELV recycling infrastructure, vehicle deregistration, and lack of access to information about ELVs (Muiruri 2014). Vehicles are widely used and frequently abandoned because of Malaysia's lax regulatory framework (Shameem et al. 2014). Inadequate ELV recycling facilities, a landfill that is overflowing, and environmental harm caused by abandoned cars are all considered to be severe problems in Malaysia (Azmi et al. 2013). Prior studies have also discovered that rare metals, such as valuable metals, run the risk of being lost if they end up in landfills, are burned as waste, or are disseminated

in other recovered materials. This is in addition to the challenges in monitoring the recycling of ELVs (Andersson et al. 2017; Nakamura et al. 2012; Ohno et al. 2014).

CONCLUSION

Malaysian ELV recycler practices start when the relevant documentation for dismantling is examined before all ELVs are transported to the facilities for dismantling. The mercury, batteries and other polluting materials will then be taken out of each ELV and stored during the de-pollution step. The ELVs will then be disassembled. The market for used spare parts is where the usable parts are gathered at this point. The severely damaged or useless components are separated into their materials and sold to recyclers. On the other hand, pieces that cannot be recycled or sold are thrown away (Azmi et al. 2013).

As we can see from the information above, Japan has a very organized framework for processing the more than three million ELVs produced between 2005 and 2011 (Hiratsuka et al. 2013) and even more ELV produced as of the time of this writing. Since all information about ELVs has been accurately documented and updated in the JARC system, there have been no material, informational, or financial leaks. Although Malaysia's implementation of the present ELV recycling procedure is a promising beginning, we truly need to catch up with the other ASEAN nations rapidly. Malaysia continues to have confusing financial, informational, and material flows due to problems with organizational management and facility readiness. The Malaysian government must respond quickly to handle abandoned vehicles by upgrading infrastructure and minimizing pointless processes to get rid of ELVs. To increase the accessibility of managing ELVs, we must adopt ELV recycling laws and regulations, add more AATFs, and increase cooperation with related sectors. The Malaysian society should receive ELV education and awareness training, as we need to change our mindset to recycle old automobiles and protect the environment. Everything comes down to the government's actions and personal perception. The government should raise this issue and commit a significant sum of money to develop an effective ELV recycling programme. The execution of each strategy is crucial, and more research is required to understand recycling, which is the extraction and recovery of all metals for reuse rather than waste. We must both keep in mind that recycling metals means protecting and saving the Earth, which is part of our social obligation. It has long been understood how important ELV recycling is for reducing the environmental impact of ELV trash. Reduced reliance on primary resources is achieved through the recovery of secondary resources from the recycling of ELVs, including ferrous metals, non-ferrous metals, and precious metals. This encourages efficient resource usage and conservation. In certain affluent nations, a recycling system has been built, and ELV recycling laws have been passed, but this has yet to be carried out in developing nations.

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