End-of-Life Vehicle Management Systems in Major Automotive Production Bases in Southeast Asia: A Review

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Abstract: End-of-life vehicle (ELV) management is becoming increasingly important as the automotive industry is one of the world’s most critical sectors and is rapidly expanding. ELV management is essential for environmental protection and wellbeing under Sustainable Development Goal (SDG) 3, provides more jobs under SDG 8, and promotes a circular economy under SDG 11. All these factors contribute to the importance of ELV management as a research topic. Today, ELV management is well-positioned and an emerging research area particularly on ELV recycling systems in Europe, Japan, Korea, Taiwan and China. This paper aims to provide a review of ELV management in Malaysia, Thailand and Indonesia, which are the major automotive production bases in Southeast Asia, but which lack formal ELV recycling policies. Towards this end, the researchers have adopted a qualitative study in which document research has been used to analyze existing scientific studies and other published sources. The findings reveal that immature ELV management systems in Malaysia, Thailand and Indonesia are the reason that no specific ELV laws and regulations exist, as well as why there are no precise ELV statistics. Nevertheless, there have been growing concerns about ELV management, as evidenced by environmental regulations and programs aimed at better management of ELV recycling in these countries. These findings will assist the respective authorities in formulating specific laws and regulations that will ensure sustainable management of ELV and will also ensure a better life and economy for society and for industry.

Keywords: end-of-life vehicle; management; laws and regulations; recycling; Asia; review

1. Introduction

The automotive industry has always been at the heart of the industrialization plans of developing countries due to three main factors: firstly, the establishment of the automotive industry stimulates a large amount of employment, investment, and consumption. The automotive industry provides new jobs and promotes economic growth under SDG 8, which reduces poverty in society under SDG 1. This, accompanied by better automotive waste management, will eventually ensure good health and wellbeing under SDG 3. Secondly, the automotive industry has always been thought to generate several significant backward and forward linkages, both with services and manufacturing activities, resulting in spillover effects to the entire economy under SDG 11. Lastly, and for the reasons stated above, the automobile has historically served as a metaphor for the entire process of capitalistic development of societies, rather than just a mode of transportation [1]. In 2020, approximately 78 million new motor vehicles had been manufactured globally and the annual production of automobiles had reduced by 15.22% compared to 2019 (92 million) [2]. Additionally, global car sales in 2020 were 63.8 million units, a 14.82% decrease from 74.9 million units in
The decrease, both in terms of motor vehicle production and the number of cars sold globally, was primarily caused by the economic recession caused by the COVID-19 pandemic. According to the International Organization of Motor Vehicle Manufacturers (OICA), more than 1.28 billion vehicles had been in use worldwide in 2015, with passenger cars accounting for approximately 947 million of those [4]. Furthermore, more than 1.68 billion vehicles are expected to be on the road worldwide by 2040 [5]. In 2019, the number of passenger cars on the road in the European Union had reached 242.7 million [6].

Automobiles have grown in popularity around the world, including in Southeast Asia, where more than 228.7 million motor vehicles were registered in 2020 [7], an increase of approximately 0.76% over the previous year. According to the ASEAN Stats Data portal, the total number of registered road motor vehicles in Southeast Asia countries had been approximately 2.4 billion from 2008 to 2020, as presented in Table 1. Among the ten Southeast Asian countries, Indonesia currently has the most registered road motor vehicles (approximately 1.4 billion), which is more than half of the total number of registered road vehicles in the Southeast followed by Thailand (approximately 450 million) and Malaysia (approximately 327 million). Thailand ranked among the top 20 major countries in terms of automotive production and sales in 2009 and 2010 [8]. Furthermore, Thailand is now one of the world's leading producers and exporters of automobiles and auto parts [1]. Indonesia also currently ranks among the top 20 major countries in terms of automotive sales [8]. Meanwhile, Malaysia, Southeast Asia's third-largest automotive market after Thailand and Indonesia [9], registered 508,911 new passenger and commercial vehicles in 2021 [10], led by national brands such as Proton and Perodua [9].

Table 1. Total number of registered road motor vehicles (in thousands) for ASEAN countries. Adapted with permission from Ref. [7]. 2022, ASEAN Stats Data Portal.

<table>
<thead>
<tr>
<th>Year</th>
<th>Indonesia</th>
<th>Thailand</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Myanmar</th>
<th>Viet Nam</th>
<th>Lao PDR</th>
<th>Singapore</th>
<th>Cambodia</th>
<th>Brunei</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>61,685.06</td>
<td>26,417.35</td>
<td>17,970.9</td>
<td>5891</td>
<td>1994</td>
<td>947</td>
<td>768.61</td>
<td>895</td>
<td>215.48</td>
<td>205.62</td>
<td>116,990</td>
</tr>
<tr>
<td>2009</td>
<td>67,336.64</td>
<td>27,184.58</td>
<td>19,016.78</td>
<td>6220</td>
<td>2068</td>
<td>1138</td>
<td>886.35</td>
<td>926</td>
<td>307.05</td>
<td>163.85</td>
<td>125,243</td>
</tr>
<tr>
<td>2010</td>
<td>76,907.13</td>
<td>28,484.83</td>
<td>20,188.75</td>
<td>6634.86</td>
<td>2299</td>
<td>1274</td>
<td>1008.88</td>
<td>946</td>
<td>260.97</td>
<td>113.66</td>
<td>138,117.9</td>
</tr>
<tr>
<td>2011</td>
<td>85,601.35</td>
<td>30,194.94</td>
<td>21,401.27</td>
<td>7139</td>
<td>2354</td>
<td>1463</td>
<td>1089.61</td>
<td>957</td>
<td>251.73</td>
<td>148.19</td>
<td>150,600.1</td>
</tr>
<tr>
<td>2012</td>
<td>94,373</td>
<td>32,476.98</td>
<td>22,702.22</td>
<td>7463</td>
<td>3614.26</td>
<td>1590</td>
<td>1288.3</td>
<td>970</td>
<td>273.16</td>
<td>238</td>
<td>164,986.9</td>
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<tr>
<td>2013</td>
<td>103,913</td>
<td>34,624.41</td>
<td>23,819.26</td>
<td>7690</td>
<td>4017</td>
<td>1669</td>
<td>1439</td>
<td>974</td>
<td>282.14</td>
<td>261</td>
<td>178,688.8</td>
</tr>
<tr>
<td>2014</td>
<td>113,354</td>
<td>35,835.18</td>
<td>25,101.19</td>
<td>8081</td>
<td>4908</td>
<td>1837</td>
<td>1577.17</td>
<td>972</td>
<td>344.25</td>
<td>294</td>
<td>192,303.8</td>
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<tr>
<td>2015</td>
<td>120,786</td>
<td>37,301.02</td>
<td>26,301.99</td>
<td>8570</td>
<td>5358</td>
<td>2107</td>
<td>1717.5</td>
<td>957</td>
<td>398.5</td>
<td>391</td>
<td>203,482.1</td>
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<tr>
<td>2016</td>
<td>128,069</td>
<td>37,338.14</td>
<td>27,613.26</td>
<td>9250</td>
<td>6126.29</td>
<td>2516</td>
<td>1850</td>
<td>956</td>
<td>525.76</td>
<td>396.38</td>
<td>214,636.8</td>
</tr>
<tr>
<td>2017</td>
<td>130,562</td>
<td>38,308.76</td>
<td>28,738.18</td>
<td>10,411</td>
<td>6801</td>
<td>2902</td>
<td>1978</td>
<td>962</td>
<td>441.8</td>
<td>408.99</td>
<td>221,513.7</td>
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<tr>
<td>2018</td>
<td>140,785</td>
<td>39,551.79</td>
<td>29,956.47</td>
<td>11,595</td>
<td>7215.5</td>
<td>3274.37</td>
<td>2105</td>
<td>957</td>
<td>580.9</td>
<td>426</td>
<td>236,447.5</td>
</tr>
<tr>
<td>2019</td>
<td>126,416</td>
<td>40,712.05</td>
<td>31,214.77</td>
<td>12,745</td>
<td>7333.98</td>
<td>4300</td>
<td>2233.69</td>
<td>973</td>
<td>646</td>
<td>439.52</td>
<td>22,699.4</td>
</tr>
<tr>
<td>2020</td>
<td>131,083</td>
<td>41,471.35</td>
<td>32,378.17</td>
<td>11,851.19</td>
<td>7610.81</td>
<td>0</td>
<td>2437.79</td>
<td>974</td>
<td>456</td>
<td>452.59</td>
<td>228,714.9</td>
</tr>
<tr>
<td>Total</td>
<td>1,380,871</td>
<td>449,331.4</td>
<td>326,403</td>
<td>113,660.1</td>
<td>61,726.84</td>
<td>25,017.37</td>
<td>20,379.89</td>
<td>12,419</td>
<td>4981.73</td>
<td>3934.79</td>
<td>2,398,725</td>
</tr>
</tbody>
</table>

A large number of end-of-life vehicles (ELVs) are awaiting appropriate treatment as a result of increased automotive production and high consumer demand for new vehicles [11]. For instance, in 2018 the European Union generated 6.083 million ELVs with a total weight of 6.732 million tons (including waste parts) [12]. In the fiscal year 2020, approximately 3.15 million vehicles in Japan had reached the end of their life cycle [13]. Furthermore, according to D’Adamo et al. [14], the annual production of ELVs in Europe is expected to reach 8.1 million tons by 2030. ELVs have been receiving special attention due to their large size, harmful components and valuable materials such as base metals (e.g., iron and aluminum) and critical metals (e.g., rare earth elements) [12,15]. ELV reuse, recovery and recycling are encouraged for a variety of economic and environmental reasons [16]. When a vehicle reaches the end of its useful life naturally, known as “natural ELV”, or when a vehicle has not reached its lifetime, but is ended by a disaster such as flooding or an accident, also known as ‘premature ELV’, it must be properly managed to recover useful materials, particularly metals, and to avoid environmental pollution [17]. Understanding of recycling and quantitative flow of ELVs is critical due to their resource recovery potential as
well as the environmental impact posed by their toxic chemicals upon disposal [18]. ELVs are usually composed of 20,000 to 30,000 different parts, which include plastics, ferrous and non-ferrous metals, textiles, rubber, wires, glass and a variety of other materials. Some of the materials are valuable resources such as zinc, iron, aluminum, copper, platinum and lead, but the composition varies depending on the model of vehicle, type, manufacturing year and size. Reusing auto parts such as tires, glass, transmission, engines, batteries, doors and seats from ELVs is beneficial in terms of resource conservation if vehicle safety is maintained. As a result, before proceeding with the dismantling and shredding steps, ELV dismantlers must obtain detailed material compositions in order to identify reusable parts on the market.

In addition to a significant portion of precious resources, ELVs also contain harmful and toxic constituents, such as brake and transmission oils, anti-freeze, engines, fuels, heavy metals, refrigerants, lead–acid batteries and brominated flame retardants. When toxic materials are improperly handled or improperly disposed of, they can endanger human health and the environment [19]. Oil fluids remaining in ELVs can leak into nearby soils or streams during disassembly, while brominated flame retardants such as polybrominated diphenyl ethers in seat fabric [18] from plastic materials in ELVs can be emitted into the air. Although such chemical components may exist in only a small percentage of vehicles, they may account for a significant amount of toxic chemicals when the total cumulative volume of ELV streams is considered.

As a result, ELV management is now one of the most critical environmental and economical topics [20,21] to achieve SDGs 1, 3 and 11, which deal with poverty eradication, good health and wellbeing, as well as sustainable cities and communities, respectively. For instance, automotive parts remanufacturing has grown to be the largest remanufacturing industry in the United States in terms of employee count, number of companies and economic contribution [8]. By 2030, it is estimated that 89% of recycled ELVs will contribute to Europe’s gross domestic product (GDP) [14]. Automotive remanufacturing, according to Petrauskiene et al. [16], serves as a specific circular marketing system for the reuse of recovered parts, which can bring economic benefits for both consumers and the dismantling companies. In 2020, approximately one million tons of ELVs had been processed by dismantling and shredding treatment for the recovery of reusable and recyclable materials (803,000 tons), resulting in 78,300 tons of automobile shredding residue (ASR) [18]. According to Abdullah [22], waste sheet steel from 960 ELVs per day can be reclaimed, avoiding the production of 265,517 tons of new sheet steel and 413,806 tons of carbon emissions, resulting in an estimated 126 billion Euros in eco-cost savings per day. Further, the reclaiming unit can generate an extra 1.823 billion Euros in sales for the plant.

The management of ELVs is a key element of global sustainability. The management of ELV recycling within a legal framework is becoming increasingly important, especially in reducing the negative impact of ELVs on the natural ecology as well as significantly contributing to efficient resource utilization and economic development. ELV recycling legislation initiatives exist in high-income countries such as the EU, Japan, Korea, China and Taiwan [23]. However, there appears to be a lack of formal ELV recycling policies in Malaysia [24–26], Thailand [27–29] and Indonesia [30,31] where automobile ownership is rapidly increasing. As a result, it is therefore critical to investigate how these three developing Southeast Asian countries, Malaysia, Thailand and Indonesia, manage their ELVs despite the absence of their own ELV laws and regulations.

However, only a few research papers on ELV issues have been published in Malaysia and Thailand. Harun et al. [32] and Ahmad Nawawi et al. [33] have investigated public perception of ELV and ELV implementation in Malaysia, respectively, whereas Azmi et al. [25] have proposed a framework for the implementation of an ELV recycling system in Malaysia while Amelia et al. [24] have identified the existing conditions of automotive reuse in Malaysia. Mangmeechai [27] provided an overview of Thailand’s current ELV management situation as well as policy recommendations for ELV management. Meanwhile, ERIA [31] have undertaken research regarding vehicle recycling in ASEAN and other Asian countries.
Hence, the goal of this study is to first investigate the ELV management systems in Malaysia, Thailand and Indonesia, as well as to provide an overview of best practices in ELV management systems in selected developed Asian countries, namely Japan, Korea and Singapore. The benchmarking exercise of these countries is pertinent because Malaysia, Thailand and Indonesia are the top three automotive production bases in ASEAN, while regulated ELV management in Japan and Korea provides great learning opportunities for Malaysia, Thailand and Indonesia. The practices of the selected countries are also comparable when they are based on each country’s GDP. Singapore, despite having no ELV regulations, has successfully reduced the number of ELVs and has avoided vehicles proceeding to ELV status by practicing a quota system to limit the number of vehicles on the island. Singapore, with a total land area of 728.6 square kilometers, is one of the smallest countries in the world, rapidly transitioning from a low-income country to a high-income country, with annual income per capita reaching 34,987.012 USD in December 2020 [34], higher than Japan (20,128.854 USD) [35] and Korea (19,081.079 USD) [36] in December 2021.

This paper provides a basis for more detailed country-specific studies on the policies and practices in ELV management, which is of special relevance for policymakers and industry practitioners in Southeast Asian countries with automotive production capacity and where governments have expressed interest in facilitating the management of ELVs. Best practices models from developed Asian countries such as Japan, Korea and Singapore have been referred to in order to bridge the gap, with the end goal of translating research into useful policy recommendations, which, in this instance, should optimize the benefits of proper ELV management for both foreign and local scenarios while mitigating the risks.

The outline for the review paper is as follows. The methodology is discussed in Section 2. In Section 3, we provide an overview of ELV management best practices in Japan, Korea and Singapore for benchmarking purposes. Section 4 analyzes the current state of the ELV management system in Malaysia, Thailand and Indonesia. Section 5 is the discussion and limitation, while Section 6 is the conclusion.

2. Methodology

This paper analyzes the ELV management systems in Japan, Korea and Singapore, while highlighting the laws and regulations which have been effective in regulating ELV in these countries. The paper then evaluates the current state of ELV management systems in Malaysia, Thailand and Indonesia. To this end, the researchers adopted a qualitative study in which document research or review of documents were used to analyze existing scientific studies and other published sources. The data and information were derived from a variety of secondary sources including published articles, documents from government agencies as well as local authorities, news, published official reports and theses. The benchmarking analysis of best practices in ELV management systems in Japan, Korea and Singapore was then used as a basis for recommendation on how Malaysia, Thailand and Indonesia should move forward in sustainably managed ELV in their respective countries.

3. ELV Management System: Best Practices from Developed Asia Countries

3.1. ELV Management Regulation in Japan and Korea

A market-based ELV recycling flow had already been established across Japan before the implementation of the ELV Recycling Law. As such, ELVs were being collected by vehicle retailers, the valuable parts were being collected by dismantling workers, shredding operators were collecting non-ferrous and ferrous metals via shredding, and finally the ASR was almost completely disposed of in secure final disposal sites with no leachate control. However, measures to prevent illegal dumping and improper industrial waste treatment, leaving ASR, were needed. To ensure the proper treatment of ELVs, the ASR was obliged to go into landfills in control-type final disposal sites in 1995, where liquid fuels, lead batteries, coolant, oil and fluorescent tubes containing mercury were needed to be separated from ELVs before shredding [37]. However, because of the increase in ASR landfill costs and the volatile price of ferrous scrap, ELVs frequently became unsellable.
Hence, the existing market-based ELV recycling system failed, raising concerns about illegal dumping and improper treatment of ELVs. As a result of discussion in government councils about establishing the new ELV recycling system, the Law for the Recycling of ELV Vehicle was enacted in 2002 and enforced in 2005 [23], as reported in Table 2. With the need to reduce ASR due to a lack of final disposal sites, and effective use of resources, as well as to prevent illegal dumping and inappropriate treatment of ELV due to fluctuations in the steel scrap market [23], the ELV Recycling Law intended to establish appropriate roles among relevant players such as automobile manufacturers, vehicle owners, dismantling firms, ELVs collectors, resource recycling companies, fluorocarbons recycling enterprises and industry associations [38] to promote sound treatment and recycling ELVs.

The ELV recycling law is one that has been specifically enacted for automobile scrapping and recycling disposal. The ELV Recycling Law also stipulates the reuse, recycling and energy recovery rates for ASR as 30% and 50%, beginning from 2005 to 2009 and 2010 to 2014, respectively [23], while the recycling rates for airbags and ASR from 2015 are 85% and 75%, respectively [23]. The Japan Automobile Recycling Promotion Center (JARC) is an organization responsible for the operation of the recycling system [37]. The Ministry of Economy, Trade, and Industry and Ministry of Environment have designated JARC as the designated corporation in charge of the fund management corporation, the information management center and the designated recycling organization as presented in Figure 1. JARC, as the information management center, manages the electronic manifest system [23,37], which covers all transactions between relevant operators in the ELV flows. When collecting and delivering ELVs, gas generators, fluorocarbons, dismantled vehicles and ASR, the relevant operators report to the manifest system. Furthermore, the ELV Recycling Law specifies the responsibilities of automobile manufacturers and importers for the recycling of airbags and ASR, as well as the safe treatment of fluorocarbons, but the recycling fees must be paid by the vehicle owner [37–39].

Figure 1. Material, information, and financial flow of ELVs in Japan “Adapted with permission from Ref. [37]. 2014, Hiratsuka et al”. Note: “FC” stands for fluorocarbons; “GG” stands for gas generators; “DV” stands for dismantled vehicles.
In Korea, the Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles was enacted in 2007 and enforced in 2008 [37], and is quite similar to EU Directive 2000/53/EC. Before this act, the Korean government’s waste management policy had been based on extended producer responsibility (EPR). This act has strengthened the EPR policy, which has been incorporated into the integrated product policy through the implementation of the eco-assurance system [40].

The eco-assurance system necessitates, firstly, preventive management, which guarantees environmentally friendly design and manufacture of products, and, secondly, follow-up management, which guarantees environmentally sound waste management. Furthermore, this act assigns responsibility for ELV recycling to all the stakeholders involved, including manufacturers, dismantlers, shredders, importers, refrigerant gas processors and ASR recyclers, and mandates the recycling rate. Each stakeholder should participate in the recycling and treatment of ELVs by fulfilling their obligations at each stage following the Act’s ELV recycling and treatment standards.

The recycling rate is determined by presidential decree. The mandatory target recycling rate was set at a minimum of 85% before 2015 (including less than 5% energy-recovery rate), and at least 95% at the beginning of 2015 (including less than 10% energy-recovery rate). When the cost of ELV recycling exceeds the price of the ELV, the excess cost is borne by the importers and manufacturers. Besides that, the importers and manufacturers must submit information on recycling performance to the Korea Environment Corporation (KECO), which is then reported to the government [23].

Table 2. Comparison of ELV systems in Japan, Korea and Singapore “Adapted with permission from Ref. [23]. 2014, Sakai et al.; Ref. [37]. 2014, Hiratsuka et al.; Ref. [41]. 1994, Koh and Lee”.

<table>
<thead>
<tr>
<th>ELV law and regulation/System</th>
<th>Japan</th>
<th>Korea</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enacted year</td>
<td>2002</td>
<td>2007</td>
<td>-</td>
</tr>
<tr>
<td>Enforced year</td>
<td>2005</td>
<td>2008</td>
<td>1990</td>
</tr>
<tr>
<td>Background of the management system</td>
<td>1. Lack of final disposal sites 2. Illegal dumping of ASR 3. Effective use of resources</td>
<td>1. Measures for ELVs 2. Effective use of resources 3. Management of information on ELVs</td>
<td>Control the increase in vehicle population</td>
</tr>
<tr>
<td>Organization responsible for recycling system operation</td>
<td>Japan Automobile Recycling Promotion Center (JAPC)</td>
<td>Korea Automobile Manufacturers Association (KAMA)</td>
<td>-</td>
</tr>
<tr>
<td>Parties responsible for recycling costs</td>
<td>First owner, upon purchase</td>
<td>Automobile manufacturers and importers (if the recycling incurs costs), and finally users</td>
<td>-</td>
</tr>
<tr>
<td>Recycling target</td>
<td>Airbag: 85% ASR: 70% (from 2015 onwards) 90% (2010 to 2014) 30% (2005–2009)</td>
<td>Until 2014 Material and energy recovery: 85% (of which energy recovery rate is within 5%) After 2015: Material and energy recovery: 95% (of which energy recovery rate is within 10%)</td>
<td>(1) All vehicles (including passenger cars, goods vehicles/buses, motorcycles &amp; open category) (2) Exemptions include: scheduled buses, school buses, emergency vehicle, trailers, diplomatic vehicles, and vehicles for the disabled</td>
</tr>
<tr>
<td>Vehicle type/Target automobile</td>
<td>All vehicles (excluding buses, passenger cars, trucks, etc.) except for two-wheeled vehicles</td>
<td>(1) Four-wheeled vehicles with nine seats or less, including passenger vehicles (2) Freight vehicle/truck weight below 3.5 tons in total</td>
<td>-</td>
</tr>
<tr>
<td>Information management</td>
<td>Electronic manifest system</td>
<td>Intensified collection of information on deregistration and recycling</td>
<td>Certificates of entitlement (COE) transferable and nontransferable auctions</td>
</tr>
</tbody>
</table>
3.2. ELVs Recycling System in Japan and Korea

Despite the existence of a legislative management system, the recycling flow of ELVs has been found to be nearly identical in Japan and Korea. Figure 2 depicts the overall flow of ELV recycling under legislative management systems in Japan and Korea respectively. As presented in Figure 2, when a vehicle becomes an ELV, the owner is required to deliver it to a collection operator. The collector operator delivers the ELV to fluorocarbons recovery if it contains fluorocarbons; otherwise, the ELV is handed over to a dismantling operator. The dismantling operator collects the valuable materials and parts for reuse and recycling, such as tires and engines, while removing certain items such as batteries and fluorescent lamps. Then, the shredding operator shreds the dismantled vehicle and collects valuable scrap metal that is delivered to the importer or vehicle manufacturer. Otherwise, the dismantling operators and shredding operators deliver dismantled vehicles to scrap dealers who buy whole dismantled vehicles. The scrap dealers then utilize the dismantled vehicles as the raw materials of steel and iron or export them as raw materials. The sorting process is essential for classifying ferrous and nonferrous metal materials. This makes use of an air classifier and the magnetic drum method. To separate non-ferrous metal, heavy media or eddy are used. Figure 3 shows the flows of reuse, recycling and energy recovery of ELVs in Japan, where approximately 99% of ELVs by weight are recycled, reused and recovered as nearly all materials and components, and of ELVs other than ASR (1%) are reused and recycled.

![ELV Recycling Flow Diagram](https://example.com/ELV-diagram.png)

**Figure 2.** ELV recycling flow under legislative management systems in Japan “Reprinted with permission from Ref. [23]. 2014, Sakai et al”.

![ELV Recycling Flow Diagram](https://example.com/ELV-diagram.png)

**Figure 3.** Reuse, recycling, and energy recovery flow of ELVs in Japan “Reprinted with permission from Ref. [37]. 2014, Hiratsuka et al”.

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Figure 3. Reuse, recycling, and energy recovery flow of ELVs in Japan “Reprinted with permission from Ref. [37]. 2014, Hiratsuka et al”.

Figure 4 displays the flow of the ELV recycling and management system in Korea according to KECO. The recycling and management system of ELVs involves several stakeholders including dismantling facilities, ASR-treatment facilities, shredding facilities, manufacturers and importers, and refrigerant-treatment facilities. ELV transporters working with dismantling facilities collect the vehicles from owners either with or without billing the treatment cost, with a market price after deregistration in a local municipality. Automobile manufacturers and importers (or producers) who have contracts with the transporters are also needed to gather ELVs from the owners free of charge, often offering them economic incentives based on market value. In addition, they also contribute to the recycling system by covering the ELV collection and recycling costs when the ELV market price is much less than both costs, while the transporters deliver ELVs to designated automobile-dismantling facilities for both manual and mechanical disassembly processes by recovering reusable and recyclable parts as well as by recovering gases and liquids for proper treatment. After dismantling, the remaining fraction is separated into ferrous and non-ferrous fractions using screening, hammer mill, magnetic, optical, density and manual separations in shredding facilities. The final residue is referred to ASR and is delivered to ASR-treatment facilities. The residue, which is usually composed of textiles, metals, wires, plastics, rubbers, sponges and glass, is approximated to be between 15% and 40% of the ELVs’ total weight. The residue is further processed at the ASR facilities to recover the ferrous and non-ferrous metals as well as glass, rubber and plastics.
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Figure 4. ELV recycling and management system in Korea “Reprinted with permission from Ref. [42]. 2021, KECO”.

3.3. ELVs Management System in Singapore

Prior to 1990, Singapore had been imposing several regulations on the rapidly expanding motor vehicle population, including import duties, road tax, basic registration fee, ad-valorem additional registration fees (ARF) and a lump-sum registration fee [43,44]. Both the ARF and road tax, which is an ownership tax, had been raised periodically to dampen the demand and control for car ownership [43]. The ARF, in particular, had increased approximately twelvefold from 15% of the open market value of a vehicle in 1975 to 175% in 1990 [42]. Although the ARF had significantly increased the cost of vehicle ownership, it had proven insufficient in controlling or limiting the growth of the vehicle population [44].

However, rapid economic growth has had the result of raising household incomes, making these costs more affordable, and the number of vehicle owners has been growing [43]. As a result, the vehicle quota system (VQS) was implemented in May 1990 to regulate, or better control, the growth in the vehicle population in Singapore [43] and to limit the number of cars by controlling vehicle ownership [45], since the usage taxes and fees were insufficient.

Singapore’s vehicle quota system uses uniform-price auctions to distribute certificates of entitlement (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 license premiums and vehicles fluctuate in response to market demand [43]. Each quota license allows a vehicle to be on the road for ten years. At the end of this period, the owner may either de-register the vehicle or renew the license for a further five-year or ten-year period, by paying a “prevailing quota license premium” [43,46]. Following that, no further renewals are permitted [44].

Such a scheme ensures that no individual has permanent ownership rights to a vehicle and contributes to lowering the vehicle population’s age [46]. If a motor vehicle is de-registered, exported, or scrapped before the expiry of the quota license, the owner is entitled to a rebate based on the quota license premium that was paid and this is pro-rated according to the remaining validity period of the quota license [44].
The quota for new motor vehicles is determined following a targeted rate of growth in the vehicle population and considering the projected vehicle de-registration. The VQS should thus be measured by its ability to control the rate of growth in the motor vehicle population. Between 1975 and 1989, the average annual motor vehicle population growth rate was 4.4%, but fell to 2.83% between 1990 and 2002 [44]. As a result, the VQS was able to reduce both the vehicle population and its volatility.

4. Scenario Analysis of Current ELV Management Systems in Selected Southeast Asia’s Developing Countries: Malaysia, Thailand and Indonesia

4.1. ELV Management System in Malaysia

In Malaysia, ELV recycling operates autonomously based on the market mechanism. Malaysia Automotive, Robotics and IoT Institute (MARii), an agency under the Ministry of International Trade and Industry (MITI), promotes the importance of safe and proper ELV recycling with the support of the Malaysia Automotive Recyclers Association (MAARA). The primary goal is to encourage the reuse of green automotive parts while also encouraging the circular economy. MARii concludes a general ELV recycling eco-system, as shown in Figure 5, which encapsulates the parties involved in a typical flow of parts, components and material, as well as the processes involved in Malaysia. This includes how MAARA members play vital roles in the dismantling of parts, in recycling, and in disposal.

In 2018, the Malaysian Standard (MS) 2697: 2018 was developed as a guideline for developing process control systems for the reuse, repair, remanufacture, or recycling (4R) of ELV parts or components. This standard would ensure that licensed entities, also known as authorized automotive treatment facilities (AATF), properly process and dispose of ELVs. The first AAFT was launched by the Malaysia Department of Environment (DOE) in March 2021, which addressed the issue of abandoned vehicles. An AATF is a facility licensed by the DOE under section 18 of the Environmental Quality Act 1974, and where components...

Figure 5. Automotive eco-system in Malaysia.
can be disposed of, particularly those containing scheduled waste, from vehicles that have been deregistered by the Malaysian Ministry of Transport following ELV regulations.

Malaysia, as a car-producing country, has taken some steps to ensure the proper handling of ELVs. For instance, the Malaysian government launched an initiative in 2009 with RM29 billion allocated to the “Cash for Clunkers” scrappage scheme, an initiative to encourage vehicle owners to officially declare their unused or unwanted vehicles as scrap by deregistering them [47]. Owners of vehicles manufactured for more than ten years who wanted to scrap their vehicles would receive a RM5000 rebate to purchase a new vehicle manufactured by Proton or Perodua. Kualiti Alam Sdn Bhd was tasked with handling the ELVs, which were supplied by Perodua and Proton. Kualiti Alam Sdn Bhd had successfully processed approximately 48,000 ELVs throughout its operation. Unfortunately, after three years of operation, Kualiti Alam Sdn Bhd ceased operations in 2011 because the rebate allocation for the scheme had been finished.

Due to the low vehicle scrap rate and high average vehicle age on Malaysian roads, the Malaysian government proposed the gradual implementation of ELV policy in the revised National Automotive Policy (NAP) 2009. This policy required an annual mandatory inspection as a condition for renewing road taxes for all vehicles aged 15 years or more and this was the first step towards full implementation of the ELV policy [48]. The gradual introduction of ELV policy, on the other hand, encountered stiff public opposition. It was later discovered that the legislation has been enacted without proper scrutiny [25]. Additionally, the later version of NAP (2014) shifted its emphasis on the Voluntary Vehicle Inspection Policy (VVIP), which was a less superior move when compared to the contentious “full-scale ELV policy” implementation in 2009. Meanwhile, one of the strategies under Safety, Environment and Consumerism in NAP 2020 was to promote the adoption of new, more environmentally friendly technology that would address pollution issues, emphasize vehicle safety and protect consumer rights. Additionally, the National Roadmap for Automotive Aftermarket (NRAA) under NAP 2020 would provide a guide for improving and optimizing the quality of component recycling and reuse. In line with the NAP 2020, a national occupational skills standard (NOSS) on ELV—parts and component salvage is being developed, focusing on the skills and knowledge required to perform competently in the automotive parts and components salvaging and recycling industry. This will ensure environmentally responsible ELV processing in Malaysia.

Although there is no specific ELV law and regulation in Malaysia, an ELV recycling system has been in place for a long time, driven by market demand. Figure 6 depicts the ELV processing flow in Malaysia, from the vehicle owners or used car dealers to the end of life. The processing flow of ELVs had been created based on common practices. The deregistration process is carried out before the dismantling of the ELVs. ELV collectors must issue a certificate of destruction to vehicle owners, and payment is based on fixed or predetermined scrap value. ELVs have been dismantled by parties such as recyclers, disposers, parts remanufacturers, vehicle dismantling companies and shredding companies. Meanwhile, Figure 7 depicts an ELV dismantling process in Malaysia, beginning with an ELV handover by the owner and continuing until parts are compacted into blocks before being sent to other companies for the recycling process for raw material.
Figure 6. ELV processing flow in Malaysia “Reprinted with permission from Ref. [49]. 2017, MAI (Malaysia Automotive Institute)”.

Figure 7. Dismantling process of ELV in Malaysia.

Furthermore, MAARA has recently signed a memorandum of understanding (MOU) with a local university that allows for the development of a study for an action plan for the remaking of ELV [50]. They have until 2025 to develop the ELV blueprint industry. Moving
towards realizing the goal of achieving a 70% recyclability rate in 2030, the Malaysian government supports the industry in the development of significant skills and competencies, encourages the application of high technology and development of standards, while providing the necessary facilities for the automotive recycling industry. The collaboration with the government will transform the recycling industry into a regulated industry that focuses on environmental and consumer needs through the green initiatives of automotive recycling.

4.2. ELV Management System in Thailand

Despite being the largest production hub for global car manufacturers and the second-largest domestic market for automobiles in Southeast Asia, after Indonesia, Thailand has no formal policy regarding ELVs [27–29]. In addition, there are no statistics related to the number of ELVs in Thailand because the Department of Land and Transport (DLT) does not enforce the requirement for vehicle owners to de-register. Instead, after three years of failing to renew road taxes, the DLT automatically erases specific vehicles from the registration system [28].

The Thai government has raised the issue of ELV management over the years in order to eliminate waste [29], for instance, the Thai government has attempted to prohibit the importation of used vehicles and parts to protect its own automotive industries. However, in practice, such a strict restriction does not work well due to limited budget allocation, consumer and producer responsibility, or poor organization [51,52]. Automobile repair shops in Thailand are ranked first in terms of sources that generate harmful materials [53] and findings from Techakanont et al. [28] have revealed that the informal sector, such as garages and repair cars, has played a significant role in reusing, recovering and recycling old vehicles.

Figure 8 demonstrates the ELV flow in Thailand, from the user to the end of life. Because Thailand lacks ELV laws and regulations, the ELV flow has been created based on common practice [27]. First, when a car owner with insurance is involved in a car accident, the car owner takes the vehicle to a car repair shop. Typically, the insurance company sends spare or replacement parts to the car repair shop, which then returns the damaged car parts to the insurance company. An irreparable car (the repair cost exceeds the insurance premium) is returned to the insurance company and then auctioned off. The used car would then be sold by an auction company to a car repair shop, second-hand shop, or dismantling factory. Car parts are sold to recycling facilities, such as those for steel, plastic, and battery/lead recovery, after being dismantled at the factory. Used tires, steel from used cars, and lead from batteries are recycled, but at a very low rate. It has not been reported that plastic or glass from ELVs has been recycled [27].

Although there is no direct law or regulation 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 the law about waste management, but this is not directly a regulation about ELV management of how a car should be registered after being used or landfilled [53]. Other laws included the Enhancement and Conservation of National Environmental Quality Act, B.E.2535 (1992), Pollution Prevention and Mitigation Policy (1997–2016), and Environment Standards.

Regardless of ELV management in Thailand, related laws and regulations in Thailand, as well as policy, appear to inspire most people to prolong car usage without keeping their cars in good condition [53]. This is caused by factors such as the presence of a second-hand car shop marketplace reduction of annual tax registration renewal fees and the vehicle value at the time of disposal [54].
Even until 2019, ELVs in Thailand had been primarily dismantled via a labor-intensive manual process, with only a single vehicle dismantled at the factory per day. Because the dismantling process has been disorganized, resources from ELVs have not been recovered efficiently. Furthermore, it was expected that the current capacity for dismantling vehicles would be insufficient to process the growing number of ELVs in the future [55]. In response to the situation, Thailand’s Industry Ministry signed an MOU on 8 February 2019, with the Industrial Estate Authority of Thailand and Japan’s New Energy and Industrial Technology Development Organization (NEDO) to demonstrate the operation of an ELV recycling system using heavy machinery for vehicle dismantling [55]. Toyota Tsusho Corporation had been entrusted with the demonstration project work. Heavy machinery for dismantling vehicles has been introduced to formalize and optimize the ELV dismantling process, and it is now expected to dismantle 20 vehicles per day as opposed to one vehicle using labor-intensive manual dismantling. Additionally, in collaboration with Japan’s Ministry of Economy, Trade, and Industry, NEDO will also provide guidance on developing laws and regulations related to the proper and safe handling of ELVs suitable for Thailand, based on Japan’s Automobile Recycling Law. Moreover, valuable resources which cannot be processed in Thailand will be recycled in Japan, resulting in the creation of an international resource circulation system. The ultimate goal of the project is to create a model recycling system for Thailand and other Asian countries [55]. The properly recycled vehicle parts could be used in the industry to assist Thailand in reducing steel imports, as well as scrap waste from old vehicles [56].

4.3. ELV Management System in Indonesia

Domestic generation is the primary source of ELV in Indonesia, as shown in Figure 9, because the country has prohibited the importation of used cars since 2007. The red cross signs in the figure denote the author’s observation on the missing practices which usually can be found in other countries with ELV policies. ELV recycling in Indonesia has been managed by the informal sector [31] in order to comply with EU Directive 2000/53/EC or Japan’s Automotive Recycling Law of 2005. The informal sector collects and recycles...
ELVs without clear guidelines [57,58]. Originally from the informal sector, the dismantling companies collect and purchase ELVs on their own, and in some cases, the owners bring their ELVs to the company. Since the majority of ELV parts are too old, they are sold to scrap trading companies, recycling companies or steel plants rather than car owners or repair shops or used parts shops. Steel scraps from ELVs, for example, have been sent to steel plants, where they have been stored and turned into steel [31]. Although the Indonesian car demolition industry is still unrecognized, some local businesses have dismantling facilities. They buy used vehicles that can no longer be repaired from junkyards. This disassembling practice involves metal picking for wire harnesses through open combustion. The car’s body is also hand-cut and used as pieces of steel. Informal recyclers only recycle iron from vehicles, while other materials such as glass and plastic parts are processed separately [59].

Figure 9. ELV recycling in Indonesia “Reprinted with permission from Ref. [31]. 2017, ERIA”.

Although there is no national regulatory system that directly manages ELV in Indonesia [30], ELV management is subject to strict monitoring under environmental laws. Among the relevant laws and regulations are General Environmental Legislation (2009), Ratified Environmental Convention, Environmental Legislation for Waste Management (2008), Local Environmental Legislation and Provincial Environmental Legislation [31]. Additionally, ELV recycling has also been promoted by Indonesian private vehicle companies, where they practice a take-back scheme to give vehicle users the option of returning their used ELVs if they meet the following requirements: (1) the vehicle must be free from additional waste; (2) all key components such as drive systems, chassis, body, catalytic converter/electronic control units are in the vehicle; (3) the vehicle should fulfil these previous two points before being put into storage; (4) the registration documents are handed over at the same time; (5) a ‘disposal certificate’ is required; and (6) only certified dismantling facilities, certified and authorized recycling workshops, or collection points, which have been nominated by the manufacturer, are permitted to issue these certificates. When an old vehicle is returned to the manufacturer, it is drained of all fluids, including brake fluid and oil. All reusable parts and recyclable materials are then removed. Separate recycling techniques are used for recyclable materials such as large plastic parts, tires, glass and others. The rest of the bodywork is shredded and disassembled into its constituent parts. These are then recovered and reused to the greatest extent possible [31].

5. Discussion and Limitations

5.1. The Management of ELVs in Developing and Developed Asia Countries

The management of ELVs differs significantly between developing and developed Asian countries. Malaysia, Thailand, and Indonesia are the top three automotive production bases in Southeast Asia. However, the ELVs in these countries are not properly managed, which explains why there are no ELV recycling laws and regulations in place. In contrast,
developed countries such as Japan and Korea have a proper ELV management system with the existence of ELV laws and regulations. The ELVs legislations in these countries make efficient use of resources, as ELVs have arisen as a good potential secondary source of precious metals such as gold, silver and platinum group metals [60]; additionally, about 65.4 to 71% of the ELVs are ferrous metal [61,62] and are therefore regarded as a valuable resource rather than waste. It is apparent that Japan and Korea have been successful in regulating ELV, as it is carried out in a systematic order. In Japan, before the implementation of ELV law and regulation, ELV management had been based on a market-based ELV recycling system. Although the market-based system had limitations, such as improper industrial waste treatment, it had been the best option prior to the implementation of Japan’s ELV law and regulation. Singapore, on the other hand, has taken a prudent step in reducing the number of ELVs through a quota system, although there had been no specific ELV law and regulation implemented.

Even though there are no specific laws on recycling ELVs in Malaysia, Thailand, and Indonesia, these governments take ELV management very seriously. This is evidenced by the enactment of various environmental policies, such as the Environmental Quality Act (1997) in Malaysia, the Enhancement and Conservation of National Environmental Quality Act (1992) in Thailand and the Environmental Legislation for Waste Management (2008) in Indonesia to control the negative impact of ELVs. Malaysia has taken some action in order to ensure the proper handling of ELVs, such as the establishment of AATF to focus especially on the proper and sustainable disposal of abandoned cars, the “Cash for Clunkers” scrappage scheme initiative, full-scale ELV policy as well as VVIP. Meanwhile, the Thai government has taken an important step towards properly managing ELVs by signing an MOU with Japan’s NEDO. Additionally, NEDO also provides guidance on developing laws and regulations for the proper and safe handling of ELVs in Thailand, based on Japan’s Automobile Recycling Law. In Indonesia, private vehicle companies have taken the initiative by implementing a take-back scheme that allows vehicle owners to benefit from their used ELVs based on a few requirements.

5.2. Factors Impeding Effective ELV Management Systems in Malaysia, Thailand, and Indonesia

When compared to the selected developed countries, the main impediment to proper ELV management in Malaysia, Thailand and Indonesia is the economic background. To properly and successfully manage ELV, this requires the vehicle owners’ willingness to pay. The ELV Recycling Law in Japan, for example, requires vehicle owners to pay recycling fees [37,38]. This may not be a problem for citizens of high-income developed countries such as Japan, which had an annual income per capita of 19,511.958 USD in December 2019, or roughly four-to-six-times higher than developing countries such as Malaysia, Thailand and Indonesia, which had annual incomes per capita of only 5761.586 USD, 3707.218 and, 4192.769 USD in December 2019, respectively. Towing fees, not to mention recycling fees, could be a significant burden for the citizens of these developing countries. According to Lau Lee Chein, president of the Malaysia Used Vehicle Autoparts Traders Association, even if Malaysians eventually come to rely on the ability to send their old cars to an automobile scrapyard, they may be unwilling to pay for towing services if the sale of the scrap vehicle is insufficient to cover towing costs [63]. The worst-case scenario is that they either sell their old car to the local scrap metal shop or keep it as junk in their home and dispose of it in a landfill. Both actions have a significant impact on environmental sustainability because not all local scrap metal shops have the proper technology for ELV treatment. In Indonesia, for example, hazardous waste and oil liquid emitted during the dismantling process is not properly treated because the dismantling facilities lack appropriate pollution control measures [31]. Meanwhile, in Thailand, dismantling is mostly done by hand, and chlorofluorocarbons and waste oils are not properly disposed of, endangering both the environment and worker safety. This is due to an inability to implement environmental legislation.
Improper dismantling pollutes water, air and soil. For instance, unmarketable materials are dumped in undesignated areas such as rivers or roadsides, causing environmental pollution [31]. Due to the lack of effective infrastructure to process ELVs, Thailand may face serious environmental consequences as the number of ELVs increases [55]. ELV dismantlers in Japan, on the other hand, implement pollution control measures under relevant environmental regulations. Dismantlers carry out dismantling under the ELV Recycling Act’s recycling requirements [31]. Meanwhile, the abandoned cars cause several issues for both the authorities and nearby residents. The problem is that they not only take up valuable parking areas but are also an eyesore in the community [64]. Furthermore, the abandoned cars may contribute to environmental and health issues by serving as dengue mosquito breeding grounds, attracting snakes, rats and other pests as well as creating an unsanitary environment [65,66]. According to Tanyaporn [67], abandoned cars parked throughout the city have obstructed traffic, posed a safety risk and increased the risk of violent activity. In summary, abandoned cars have a negative impact on local sustainable development, which directly contradicts the 2030 Agenda for SDGs, particularly the third SDG, which is to ensure healthy lives and promote well-being, and the 11th SDG, which is to make cities and human settlements inclusive, safe, resilient and sustainable. The issue of abandoned cars is not new in Malaysia, Thailand or Indonesia, but has become more serious in recent years. For example, Malaysia had approximately eight million abandoned vehicles across the country as of November 2017 and the actual number could be higher [66]. According to Tanyaporn [67], in August 2020, approximately 500 abandoned cars parked in Bangkok city were removed. The towing process takes time because local municipalities can only tow away abandoned vehicles if the owner fails to remove them after receiving a notice and compound [64]. In Thailand, the officials are required by law to spend 15 days attempting to locate the owner of the vehicle, failing which the vehicle will be impounded by the municipality. The vehicles would be kept for approximately six months before being auctioned off by district office directors [68].

The second problem impeding the development of proper ELV management systems in these developing countries is inadequate or poor public transportation, particularly in rural areas. In Malaysia, issues of public transportation accessibility are more prevalent in rural areas than in urban areas [69]. Rural public transportation services are portrayed as ineffective and inaccessible to all. According to Dewanti and Parikesit [70], urban areas in Indonesia benefited from better public transportation services due to greater interaction between the two areas when compared to other rural areas. However, existing rural public transportation services are frequently constrained by a lack of availability and an unreliable pattern of operation. As a result, most rural people rely on private cars for almost all their travel needs. Rural mobility levels are generally higher than urban mobility levels. This is due to rural areas’ more dispersed residences and activity sites, which increases trip distances and forces reliance on the car [71]. Unfortunately, due to financial constraints, not all rural residents can afford to buy a new car, and they may consider buying old or used cars. For instance, the vast majority of Indonesians prefer to drive older or used vehicles due to financial reasons [59]. According to the findings of ERIA [31], old cars or even old types of used cars in these developing countries are likely to circulate from urban to rural areas, implying that old cars in cities are generally resold to people in rural areas where they are still used. As a result, ELVs can be found in rural areas of these developing countries.

Some of the old cars or used cars have been around for more than 15 years, but their owners claim that with proper maintenance, these vehicles can still be relied on for short-distance travel. Unfortunately, old cars deteriorate not only in terms of roadworthiness but also in terms of safety features such as body strength, lack of modern technologies in both active and passive safety, and, to make matters worse, a lack of proper vehicle inspection. In Japan, periodic vehicle inspections are carried out following the law by the Minister of Land, Infrastructure, Transport and Tourism [72]. That is, a used car must pass these inspections every two years to be used for driving and be issued with an effective vehicle inspection certificate. In an ideal world, the old cars should be replaced and the
ELV system should force them to retire [73]. However, implementing an age limit for passenger vehicles may be difficult, particularly in rural areas, even though the majority of respondents (79.8%) in a recent study conducted by a group of Malaysian Institute of Road Safety Research (MIROS) researchers believed the age limit for a car should be between five and ten years [73]. Furthermore, 268 respondents, or 55.4% agreed with the suggestion to implement an ELV policy with a guideline on passenger vehicle age limit. Their study, however, only included respondents from Selangor, one of the states with the highest per capita income [74]. Hence, their findings and opinions on the agreement to impose a passenger vehicle limit cannot be generalized across the country and must be thoroughly investigated.

A lack of awareness about ELV management systems is another significant impediment to the development of proper ELV management systems in these developing countries. The Indonesian government had attempted to enact regulations requiring periodic emissions testing, but these were quickly repealed due to massive public opposition [59]. Low environmental awareness contributes significantly to the difficulties faced by the Indonesian government in developing ELV management policies [59]. Furthermore, in Malaysia, the government once proposed gradual implementation of ELV policy in the revised NAP 2009 but quickly removed it due to public outrage upon its announcement. It is perhaps unique to Malaysia that any new changes to the so-called “routine” in society causes an immediate public outcry and negative perception, even if the initiatives are for the betterment of the country’s future both environmentally and economically. This could be due to a lack of understanding about the importance of proper ELV management and the consequences of poor ELV management. According to a recent Malaysian study on ELV awareness and understanding in Malaysia, most of the respondents have little knowledge of ELV [33]. Malaysians are aware of general or basic recycling but are unaware of the specific issue of ELVs recycling. Another recent study discovered that public awareness and acceptance of ELV implementation are quite low in Malaysia [32].

5.3. Current ELV Management Practices in Malaysia, Thailand and Indonesia: Long-Term Impact

If current practices in these three developing countries, Malaysia, Thailand and Indonesia remain unchanged and no effort is made to develop standard ELV recycling laws and regulations, such as the ELVs Recycling Law in Japan or the Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles in Korea, we expect these countries to face various environmental, health and economic problems in the next five years. First, the number of ELVs will continue to rise, as evidenced by an increase in the number of vehicles produced and registered vehicles each year. Malaysia had approximately 14.698 million registered vehicles in 2019, up from 14.118 million and 12.081 million registered vehicles in 2018 and 2017, respectively [75]. Furthermore, the number of registered vehicles increased by more than a quarter (31.23%) between 2014 and 2019. In terms of old cars, in 2014 it was reported that more than five million of Malaysia’s 20 million cars on the road were between the ages of 10 and 15 years [76]. According to the Thailand Land Transport Department, there are more than 5.03 million vehicles registered on the road that are over 20 years old as of 31 January 2022, and this number is expected to rise to 16 million over the next 20 years if serious ELV recycling action is not taken [77]. Based on these figures, we can anticipate that the number of ELVs will increase over the next five years.

The increase in the number of ELVs will endanger people’s health, especially if they are not properly managed and if there are no standard ELV recycling laws and regulations in place. According to Thanakorn Wangboonkongchana, a Thai government spokesman, the prime minister expressed concern that ELVs that remain on the roads would contribute to dangerous fine particles or PM2.5, that pollute the air [77]. It has been discovered that PMs or particle pollution with diameters of 2.5 µm or less (PM2.5) have a greater impact on human health [78]. PM2.5 are capable of transporting various toxic substances through the filtration of nose hair, reaching the end of the respiratory tract with airflow and accumulating, thereby diffusing and causing harm or damage to other parts of the
body as a result of air exchange in the lungs [78]. Furthermore, when a vehicle reaches the end of its useful life, the owner has the option of scrapping it or simply abandoning it in an open space or by the side of the road. As evidenced by an increase in the number of abandoned cars, an increasing number of owners are choosing the second option. Hence, if current practices in these three developing countries, Malaysia, Thailand and Indonesia continue, the problems associated with abandoned vehicles will worsen in the future. As previously stated, abandoned vehicles cause a variety of issues, including the following: firstly, environmental issues in which abandoned cars are an eyesore and a source of pollution when burned; secondly, social issues in which abandoned cars can obstruct roads and parking spaces; thirdly, crime-related issues in which abandoned cars attract vandalism and property destruction; and finally, waste of financial resources because the majority of the high costs associated with removing, storing and disposing of abandoned cars are borne by local governments.

The proper management of ELVs will significantly contribute to the country’s economic growth. In the United States, for example, the ELV recycling industry employs over 140 thousand people, generates $32 billion in sales, and supplies roughly 37% of the country’s ferrous metals [62]. Improper ELV management, on the other hand, will result in significant economic losses for Malaysia, Thailand, and Indonesia. Thailand, for example, consumes approximately 19 million tons of steel per year, with 12 million tons imported and the remaining 7 million tons produce domestically. In fact, the Thai government can help reduce steel imports if ELVs are properly recycled so that their parts can be used in steel-related industries [77]. On average, the ELV structure contains 71% of ferrous metals and 7% of non-ferrous metals [61], making them one of the best sources of steel. Additionally, ELVs are the only source of re-useable spare parts, and with the increase in the number of vehicles approaching ELV status, as well as those that need to be repaired after a natural disaster or an accident, it is expected that the number of users of these re-useable spare parts will increase. As a result, the used spare parts industry is thought to have a high potential for increasing economic growth in these developing countries while also creating job opportunities. However, improper ELV recycling that fails to recover the re-useable parts will inevitably slow down the used spare parts industry, failing to contribute to the country’s economic growth.

5.4. Limitations

Every study has limitations, especially qualitative research based on document research. This is a pure literature review based solely on secondary data collection, such as a review of previous ELV studies and limited information from websites, with no support from primary data collection. Hence, it is recommended to use a mixed method of data collection, including findings from interviews and surveys with other stakeholders in the ELV automotive industry, such as Ministry of Transport representatives and after-market players (e.g., recyclers, manufacturers, dismantlers), to validate the findings from this study.

6. Conclusions

This study has shed light on the current ELV management systems in Southeast Asia’s top three automotive production bases. To address the current ELV management systems in these countries, the scenarios of ELV management systems in Malaysia, Thailand and Indonesia have been reviewed and discussed. This research is critical because it provides a foundation for the development of an ELV recycling framework as well as ELV laws and regulations in Malaysia, Thailand and Indonesia. Additionally, it is also expected to assist the government in drafting ELV laws and regulations. As part of sustainable and economic initiatives, future work will be required to develop a detailed framework for analyzing the existing ELVs management systems as well as for the proposition of ELVs laws and regulations. The ELV recycling laws and regulations are one of the missing pieces in the Malaysian, Thai and Indonesian automotive ecosystems, and a successful ELV management system will not only address environmental concerns but also contribute to expanding the
countries’ economic growth. Developed Asian countries such as Japan and Korea have ELV recycling laws and regulations in place to address issues involving automotive waste products, as before the implementation of their laws and regulations, the production ELVs had increased year after year, as well as increased illegal dumping and improper industrial waste treatment. Lessons can also be learned from Singapore’s practice where the vehicle quota system had successfully controlled vehicle population growth, lowering the age of the vehicle population there. Hence, proper ELV recycling laws and regulations are critical for Malaysia, Thailand and Indonesia, as the estimated number of ELVs grows each year as car production increases.

Though the Malaysian, Thai and Indonesian governments are attempting to manage ELVs in their respective countries by enacting various policies including environmental policies, memorandums and inspiring consumers and automotive manufacturers by providing various facilities, it is time to develop a standard ELV recycling policy for a proper solution to managing ELVs in order to sustain the environment and reduce human impact on nature. The ELVs disposal is a major concern for any of these developing countries striving for sustainable development. To reduce waste discharge and improve the automotive industry’s image through environmentally sound management, maximum recovery and recycling is required. When an appropriate recovery strategy is combined with the standard ELV recycling policy, significant environmental and economic benefits can be expected. Although the propositions for ELV laws and regulations are critical for these developing countries to control ELV recycling, reduce its environmental impact and maximize its benefits, a thorough examination and consideration of all potential challenges, particularly in terms of their citizens’ economic backgrounds, should be conducted and determined before the proposed ELV recycling laws and regulations are implemented, in order to reduce the burden on the people.

At the end of the day, sustainable management of ELVs will assist many stakeholders in many ways. A well-regulated ELV management system will promote new business and provide good new jobs to the community under SDG 8 and enhance economic growth. Sustainable management of ELV will protect the environment and ensure good health and wellbeing under SDG 3 and promote a circular economy under SDG 11. As a result, Malaysia, Thailand and Indonesia need to learn from Japan and Korea on how to develop a proper regulatory framework to manage ELV. This will equip them with a more formal and well-regulated ELV sector.

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