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5.6 Proposed framework for End-Of-Life vehicle recycling system implementation in Malaysia

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Abstract
Normally in Malaysia, vehicles are being used extensively regardless of its age or condition. This situation is not only in rural areas but exists in major cities. Vehicle manufacturers expected their vehicles to last in 15 years, hence vehicles exceeding this limit are considered as End-of-Life Vehicle (ELV). The extensive usage of ELV may lead to vehicle failure which threatens the safety of its user as well as other road users. ELV usage also contributes to environmental pollution. In order to overcome this, a framework for ELV management needs to be developed. Prior to that, a survey was done to study the current practice being applied in Malaysia. This paper also study the existing framework applied by other countries as adaptation for Malaysian ELV recycling implementation framework. This framework is expected to assist the government in drafting new ELV related policies.

Keywords:
ELV; Framework; Vehicle Recycling; Vehicle Recovery

1 INTRODUCTION

Total number of vehicle in Malaysia had reached a cumulative amount of 21.25 million vehicles at the end of year 2010 with an average of 12% increase of vehicle registration each year over the period of 5 years. If the estimation was to be continued, Malaysia will have as much as 31 million vehicles in the year 2020. As the automotive industry develops, its impact to the environment also increases. Thus, a proper solution of managing waste is needed to sustain the environment and reduce human impact towards nature.

The disposal of End-of-Life Vehicles (ELVs) is of high concern to achieve sustainable development in any country. Maximum recovery and recycling needed to be achieved to reduce waste discharge and to change the image of the automobile industry through environmentally sound management. Lately, ELV management has been launched extensively in developed nations to establish an appropriate recycling system using the best available technologies. For European Union, the End-of-Life Vehicle Directive has passed laws to the member countries to reuse and recover 85% by weight of the average vehicle in year 2006 and this percentage is expected to increase to 95% by year 2015.

After the establishment of National Car Project in 1985, the automotive industry in Malaysia has grown tremendously. However, Malaysia has not dealt with the environmental impact of the automotive industry sustainable development. To date, directive or legislation on End-of-Life Vehicles for the automotive industry has not been established even though an attempt was done in 2009 but later withdrawn due to fierce rejection by public. It was known later that the legislation was introduced without proper research and has too many loose ends. As a result, Malaysia have a very low vehicle scrap rate and relatively high vehicle age. Several countries in Asia have started the effort on reversing the problem of ELV accumulation or overpopulation. This campaign was triggered by the European Union (EU) with an ELV law in September 2000 and had since lead Japan and Korea to follow suit with tailored version of ELV Law. These countries recognized that a distinct ELV law is necessary within the framework of the extended producer responsibility (EPR) system. Japan, Canada and Taiwan had reported success in controlling the number of ELV off the road.

Due to the success of countries implementing ELV law, a SWOT analysis on the respective framework had also been done. The results from this analysis will be used to model a new framework ideal to Malaysian current and future condition.

2 LITERATURE REVIEW AND METHODOLOGY

Waste treatment has become an important issue and a serious concern to the environmental conscious society. Concerns about reducing waste during the generation process have been emphasized as the first priority before further treatment. Waste form ELVs is also one of the recently emerging waste streams. This had led to a need to achieve maximum recovery level with less amount of waste discharge. Among efforts to reduce the amount of ELV waste is by extending the lifetime of a vehicle, lowering exhaust gas emissions, and changing materials for easier recycling or recovery in the industry [1]. Waste treatment is required as environmental management practices and to enhance the image of automobile industries. Malaysian National car maker PROTON in response with recent EU legislations, the Directive 2000/53/EC European Commission had to change approach in designing and manufacturing of its product [2].

After 52 years of independence, the Malaysian government had introduced the National Automotive Policy to boost the countries participation in the automotive industry with aiming to be the hub of regional automotive industry. However, the National Automotive Policy has not dealt with the environmental impact of the automotive industry development. To date, directives or legislation on End-of-Life Vehicles for the automotive industry have not been established exclusively. In the EU countries, the directive is seen as a pushing factor for the establishment of an environmentally conscious automotive industry [3]. It is noted that in National Automotive Policy, ELV related policy will be introduced gradually with first implementation which was a mandatory annual inspection of vehicles with 15 years of age or older for road tax renewal. This policy however is later withdrawn.

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End-of-life vehicle recycling in Malaysia however is being done by 5000 small companies bound under associations such as Malaysia Automotive Recyclers Association (MAARA) and working without a standard working practice [4]. The business was run in similar way as regular car workshops thus a proper regulation should be in place to improve and control the current practice in recycling ELV. Vehicles usually imported from developed nations such as Japan and European countries to be dismantled and sourced for parts which are still usable and in working conditions. Unusable components then are sent to the smelter plants to be melted for recycling purpose or sent to the junkyard. Moreover, recycling resources such as engine oil and coolant of air condition units such as chlorofluorocarbon (CFC) is not appropriately handled due to lack of equipment, information and skills. Consequently global warming and soil pollution problems are accelerated. Currently, there is no exact figure available to describe the number of ELVs that have been recovered in Malaysia.

The ELVs directive is needed to boost the number of reuse and remanufacturing vehicles parts–components, increase the number of recycled materials, regulate the use of hazard or toxic materials, and facilitate OEMs in ELVs-recovery programs. As more vehicle manufacturers starting to flock into Malaysia, a regulation is developing sustainable and environmental conscious local manufacturers is seems fairly justified.

The first step for this study was to gain the current practice of ELV Recycling system in Malaysia. For this step, the author chooses to use Qualitative Data Collection and complemented with Quantitative data collection for framework validation later. Interviews seems to be the best method compared to questionnaire because the current situation is unknown or yet to be documented.

The first round of data collection was done using Qualitative data Collection techniques. The chosen methods are interviews and direct observation. A total of 8 companies had been interviewed. 2 of the interviews were done via structured interview while the rest was using participant interview techniques. Each interview only last between 20 minutes to 1 hour. Participant for this interviews are; 5 ELV Recycling companies, 2 workshops and 1 used tire reseller. The best input was provided by the ELV recycling companies.

For the interview questions, a set of open ended questions are being asked. Such questions includes details of how dismantling activities is being done, how the safety of the activities being monitored, how parts reliability and safety are being tested. Second main criteria being investigate is the shredding process while waste which being transferred to landfill is the third important criteria. The question set also includes the environmental related questions such as the awareness of the company on environmental law and legislation. Later, a questionnaire consists of a Current ELV Recycling System to respondents for validation as shown in Figure 1.

The second part which is the proposed Framework, the analysis of Strength-Weakness-Opportunity-Threat was done on several countries ELV management Framework namely Japan, Canada, Taiwan, China, and Korea which was obtained from related journals and publications. Results will then be used to model this proposed framework.

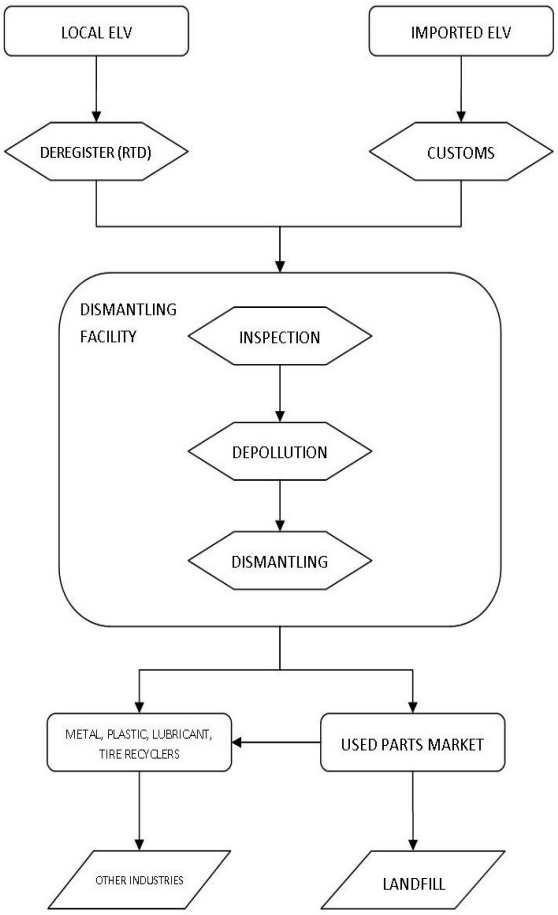

Figure 1: Current ELV recycling system in Malaysia

3 CURRENT SITUATION

3.1 Legislation Requirement

The first row of Table 1 addresses the legislation by seven countries; Taiwan, China, Korea, Japan, Canada, Singapore, and Malaysia regarding ELV recycling. All mentioned countries have enacted their own version of regulation to enforce ELV recycling except for Canada and Malaysia.

Automotive Recyclers of Canada (ARC) estimates that 600,000 vehicles leave the road annually in Ontario. This is half the total estimation of 1.2 million vehicles for Canada. Approximately 1.2 million vehicles are taken off the road annually in Canada. This creates more than 150,000 tons of vehicle waste which is introduced into landfills in Ontario alone. This volume includes contaminated materials which in time will pollute the soil. Despite his huge numbers, law on ELV is still not being introduced by the Canadian government.

In term of jurisdiction and mandatory ELV recycling (also called vehicle retirement), each province in Canada has their own regulations initiative but not in federal government level.

Table 1: Comparison of ELV management system between countries

	Taiwan [5]	**China [6]**	**Korea [7]**	**Japan [8]**	**Canada [9]**	**Singapore [10]**	**Malaysia**
Government Involvement / Act :	Waste Disposal Act	Statute 307 Law on ELV	The Act for Resource Recycling of Electrical/ Electronic Products and Automobiles	End-of-Life Vehicle Recycling Law	None (Voluntary)	Vehicle Quota System	No Law
Manufacturer Involvement:	None	None	None	Take back CFC, Airbag unit, Shredder Dust	None	None	Proton (AMP)
ELV age:	10 years	10 years or 500,000km	Not Specified	Min 3 years, inspection once in 2 years	Not specified	10 + 5 or 10 + 10 years	Proton (10 years)
Recycling Fees paid by:	Manufacturer & Importer pay when purchased	Market Driven (Collector pay last owner)	Market Driven (Collector pay last owner)	First owner, upon purchase	Market Driven (Collector pay last owner)	Market Driven (Collector pay last owner)	Market Driven (Collector pay last owner)
Operator Size:	303 Recycling operators, 5 shredding & Sorting plants	367 Recycling operators, 1 pilot recycling centre	226 Recycling operators, 7 shredding & Sorting plants	5000 Recycling operators, 140 shredding & Sorting plants	-	-	209 Recycling Operators, 0 Shredding & Sorting Plant
Effectiveness : (Recovery rate)	95%	90%	85%	85%	-	-	None
GDP Per-capita (USD):[f]	36,604	7,536	29,004	33,994	38,915	57,505	14,591

The closest Canadian Government have is the Canada-Wide Action Plan for Extended Producer Responsibility which was introduced in October 2009 [9]. ELV is indirectly included through products of “automotive products such as used oil, filters, batteries, refrigerants, brakes and transmission fluids”. It can be safe to state that Canada ELV recycling is driven by market demand as well as recycling awareness of Canadian citizen. Moreover, a complete framework of Canada ELV Recycling System is yet available which maybe one of the reasons why Canada still lacks in ELV recycling regulations. Plus there is no agency that tracks the number of ELV related materials and how they are handled except for British Columbia. Reference [9] also states that end-of-life is the least studied phase of vehicle lifecycle.

In Japan, recycling is made mandatory for all citizens and corporate entities by various laws implemented by the parliament. For the record, there are 80 million vehicles in Japan and 5 million is being disposed every year [11]. The Japan End-of-Life Vehicle Recycling law which was enacted in 2002 and came to force in 2005 was designed as a response with the increasing number of landfill due to vehicle waste in the island nation, and hike in vehicle recycling fees. The law systematically improves vehicle recycling through specification of car manufacturers and importers tasks as well as customers and government task.

The Japan Automotive Recycling System is designed to minimize illegal dumping possibilities by adopting a prior fee payment arrangement whereby the purchaser of a new vehicle must pay the recycling fee at the time of purchase, while the owner of an in-use vehicle must pay it at the time of the first periodic inspection. Moreover, the recent surge in industrial material prices has made otherwise abandoned ELVs valuable resources to be properly recycled. As a result, according to the Ministry of the Environment, the number of unlawful ELVs in Japan sharply declined from 126,000 units (92,000 units illegally stored and 34,000 units illegally dumped) in August 2001 to only 35,064 in March 2007.

One important contributor for this decline is the introduction of Licence Validity called Shaken which dictates the inspection interval of a vehicle shown in Table 2. The tough inspection was required to ensure public safety and environment sustainability via multiple point testing.

The rapid economic development of Taiwan and demand for improved quality of life had pushed the number of motor vehicles to the highest in the past 30 years. From the end of 1976 until the end of March 2009, the number of small

passenger vehicles has increased from 170,984 to 5,668,581 and the number of motorcycles has increased from 2,009,698 to 14,382,923 vehicles.

Table 2: Shaken licence validity

Vehicle		Expiry Date	
		First	Subsequent
Truck	More than 8 tons	1 year	1 year
	Less than 8 tons	2 years	1 year
Bus		1 year	1 year
Taxi		2 years	1 year
Special Vehicles		2 years	2 years
Private car and Motorcycle		3 years	2 years

According to the statistics provided by the Recycling Fund Management Board Taiwan (RFMB), there are 303 ELV recycling operators in Taiwan and five shredding and sorting plants throughout the country. Taiwan recycling legislation is introduced since 1980s under the Waste Disposal Act. The law evolved from market driven activities to today's mandatory yet profitable business.

The volume of in-use vehicles in China will reach a staggering 32 million by the end of 2006 and the volume of End-of-Life Vehicles (ELVs) will be more than 1.5 million by the end of 2005 [12]. Recent data collected on 2011 indicated that vehicle market in China set a new record with sales of approximately 13,791,000 units in 2009, bringing in a total number of vehicles to 62,880,000 units [6]. This feat has pushed China to become the largest vehicle market in the world. It is estimated in year 2007, 3,506,000 vehicles are being scrapped.

Chinese lawmaker passed a regulation for disposal and recycling of ELV in 2001 a year after European Union introduced the law. The main feature; "Statute 307" is the declaration of ELV based on mileage accumulation and duration of service as shown in Table 3.

Korea produced around 3 million vehicles in 2001. Half of it is being exported to other countries leaving 1.5 million vehicles for the local market. In 2004, the number of vehicles in Korea stands at 14 million vehicles, and 500,000 ELVs are generated annually. 80,000 ELVs are exported as second-hand cars while the remainders are collected and processed at local dismantling facilities. Koreans follows the mandatory Act for Resource Recycling of Electrical / Electronic Products and Automobiles which requires the recycling of goods including vehicles. However, some developing countries, such as Malaysia, which are in the early stages of starting their ELV recycling system, lacks ELV recycling regulations [3].

3.2 Technology of ELV Recycling

Current ELV recycling process involves two major process; In-process which involves Dismantling and Shredding, and Post-Process which involves Material Recycling and Energy Reclamation. The dismantling process normally involves manual works of harvesting higher value parts for reuse market or reconditioned by remanufacturers. Usable parts are either sold directly to users or through second hand parts traders and service garages. Dismantling process usually is labour intensive and uneconomical which serves as an advantage for countries with low labour cost such as China. Advanced countries such as Japan use various tools to assist this activity and items harvested usually of high quality and undamaged.

For Shredding process, the ELV Body Shell, severely damaged and complex parts will be sent to shredding plant to churn it into smaller and manageable sizes. The ELV will be compressed before being fed into a giant rotating drum and being shredded by a set of rotating hammer. The output which known as Automobile Shredder Residue (ASR) is then sorted by its material type where metals and non-metals being separated using magnet. The process has higher efficiency if recyclability is integrated in the design phase but the challenge is vehicles were not designed to be recycled [13].

Materials sorted from ASR will be sent to respective recycling facilities such as electric arc steel melting furnace and plastic recyclers. Remaining ASR will be sent to incineration plants. Advanced countries such as Japan uses heat produced by incineration of ASR to generate electricity thus reclaiming the energy stored in the material [14].

Table 3: China classification of ELV

Vehicle Type	Declared as ELV if:
Mini-size commercial vehicles	Mileage exceed 300,000 km
Light commercial vehicles	Mileage exceed 400,000 km
Heavy, medium commercial vehicles	Mileage exceed 400,000 km
Passenger vehicles	Mileage exceed 500,000 km
Other vehicles	Mileage exceed 450,000 km
Mini-size commercial vehicles, including trailers and taxicabs*	Service period exceed 8 years
Light commercial vehicles and others	Service period exceed 10 years
* taxicabs for 19 passengers or less, light and mini-size commercial vehicles could prolong their service period up to half of the fixed number of years if they pass inspection for compliance with national vehicle exhaust standards.	

3.3 Current ELV Recycling System in Malaysia

Based on the first round of interview, a Current ELV Recycling System (Figure 1) had been engineered. In Malaysia, ELV can come from two sources; Vehicle from local market, and Vehicle imported from overseas. All local vehicles which intended for disposal will be required for Deregistration process. This process was meant to unregister the vehicle and to notify the government through Road Transport Department (also known as Jabatan Pengangkutan Jalan, JPJ) that the vehicle is no longer in use, and to strike out the record from JPJ together with all required tax payments. This process also prevents the vehicle from being used as an accessory for crime.

Malaysia also allows its local ELV Recycling companies to import ELVs from other countries. These vehicles will require clearance from Royal Malaysian Customs office. According to the law, any importation of vehicle will require an Importation Approval Permit (or AP). This also applies to ELV importation. In recent news, the government had announced that Open AP for vehicle importation will be abolished from 31st December 2015. It is still unclear whether this move will benefit ELV Recycler or not. The companies interviewed however are confidence that the government will be more lenient with this policy later. Normally, ELV recycler will choose and import the vehicle using their own means of transportation.

All vehicles are later being sent to the Dismantling facilities. In Johor alone, there are 32 dismantling facilities from the total 209 operators registered with the Malaysian Automotive Recyclers Association (MAARA) while the biggest ELV Recycler for local vehicle are in Perak, Malaysia. Here, the documents required for dismantling will need to be inspected for the purpose of verifying ownership on the vehicle. Reputable companies will not proceed if deregistration documents procured from JPJ are not present (for local ELV) but small scale dismantler often disregard this rule. Imported vehicles on the other hand are easier and only needed customs validation. Documents required are cross checked with the vehicle engine number and chassis number.

Later, the vehicle will undergo a de-pollution stage. Here, all fluids are being drained and stored for respective recycler. Battery, Mercury and other pollutant agents are removed to storage at this stage.

Finally, the vehicle will be dismantled. Useable parts are harvested and enter used spare parts market. Unusable or heavily damaged will be sorted by their respective material which will be sold to recyclers which meant for other industries. Parts which cannot be sold or recycled will be sent for disposal.

During participant interviews and observation, it is learnt that some recyclers do not adhere to the environmental law or guidelines. For an example, engine coolant are being discharged freely into the drains, and air-conditioning gas being freely released into the air. This will lead to a serious impact on the environment. The proposed framework will be required to address this issue as an incorporated part.

4 PROPOSED FRAMEWORK

European Union had targeted to have only 5% of a vehicle weight being sent to landfill by 2015. One of its objectives is to reduce the area required for landfill. Malaysia should also follow this target. If the framework is implemented successfully, the country will be beneficial in term of less land usage for ELV dumping ground, and a new source of economy for the nation. The Framework for ELV Recycling in Malaysia as shown in Figure 2 may assist Malaysia for this ambition.

Responsibility of ELV recycling should not be burdened on users alone. Manufacturers, retailers, recyclers, users as well as government should also work together to solve this problem. The framework empowers ELV recyclers and users to recycle and promote recycling activities. Apart from that, extended responsibility for manufacturers will also suggest them to improve their product through redesign, or simply adapting the design for recyclability and sustainability.

Important parties or stakeholders are also empowered to regulate the involved process. These stakeholders are the recycling associations, government entities, and user associations. Plus, environmental law currently exist will be integrated and internally enforced by the practitioner themselves. The ELV management board will also need to collect all information regarding ELV recycling within Malaysia.

All 6R criteria proposed by reference [15] is integrated within this framework. Table 4 shows responsibilities and explanation for each activity. Manufacturers have the responsibility to reduce and redesign the materials and parts respectively. They also indirectly involves in the parts reuse. Apart from that; recyclers, re-manufacturers, part dealers and incinerator also have their own responsibilities.

4.1 ELV Management Board

The ELV Management Board is a non-governmental body which act as regulator as well as auditors for ELV recycling operators. Their function is being modelled after the Taiwan ELV Recycling Fund Management Board.

The board may also assist the government in ELV policy making by providing information and studies regarding ELV Recycling (ELVR) activities. This body is modelled after Taiwan ELV recycling system which the government, recycling associations, and user associations work together to curb ELV problem. The board also have the responsibility of setting Standard Working Practices (SOP) for dismantling, depollution, parts evaluation, and shredding activities. They also may set the standard for safety of equipment and fixed/non-fixed facilities.

Table 4: Integrated 6R within framework for ELV recycling system

Activity	Responsibility	Explanation
Reduce	Manufacturer	Reduce material variability
Reuse	Part dealers/ manufacturer agents	Sale of reusable parts collected from dismantling process
Recycle	Recyclers	Recycle used materials into raw material for manufacturer/ other use
Remanufacture	Remanufacturer	Damage but still usable parts will be remanufactured/ recondition by OEM
Redesign	Manufacturer	Design or parts for easy processing
Recover	Incinerator	Regain the energy locked in the material

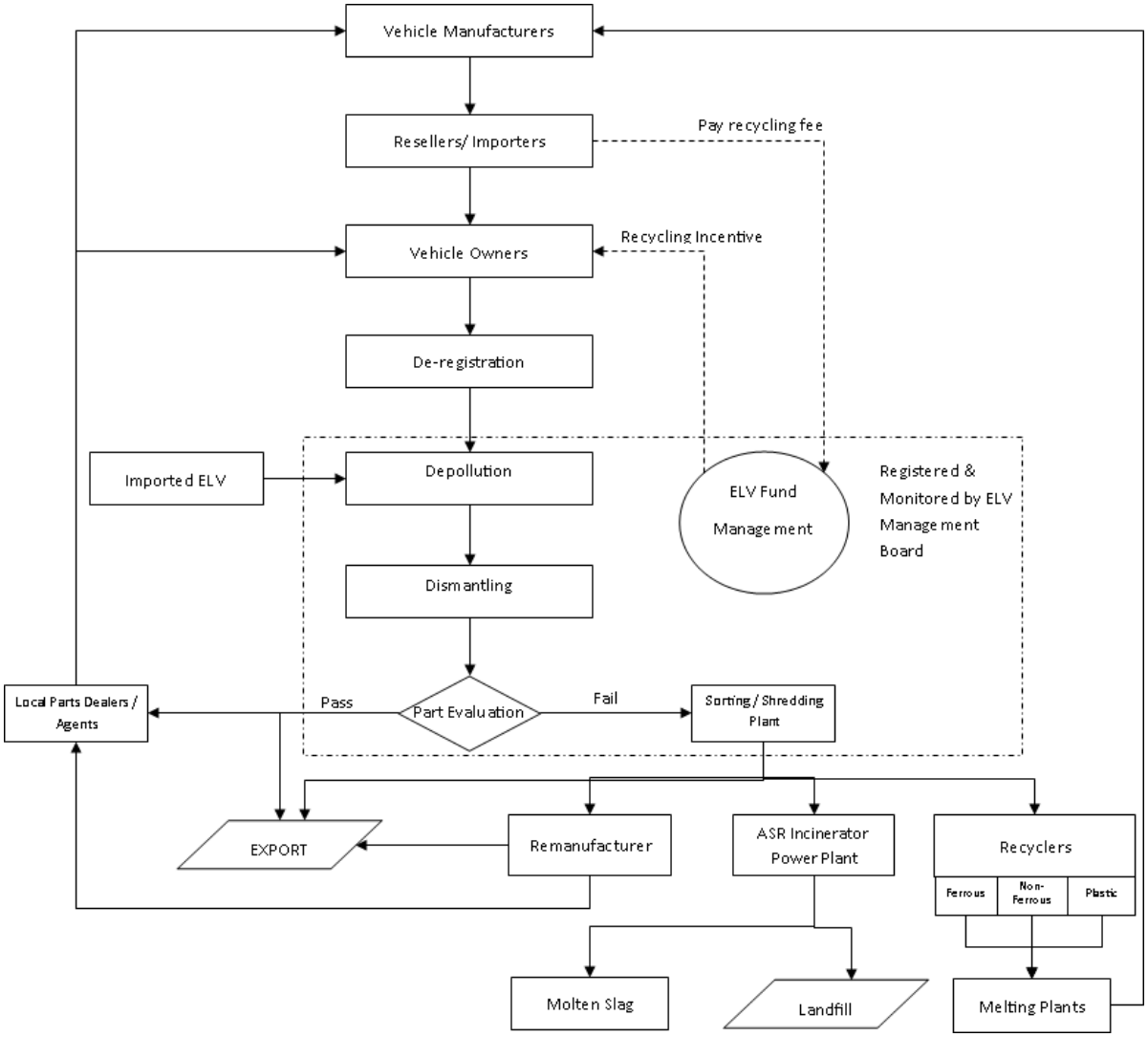

Figure 2: Proposed framework for ELV recycling system in Malaysia

Other responsibility is data collection such as number of local and imported ELVs being processed, ASR composition, economic value, recovery rate, or any data deemed useful for improvement of overall ELV recycling system and future sustainability studies.They also responsible in auditing, and provide training and expertise for ELV processors. This function was modelled by Canadian ELV recycling system which has its own Automobile Recycle Association University (ARAU), but here in Malaysia, it is better to integrate this function within the ELV Management Board. Apart from the functions listed, the board are also responsible for the ELV Fund. Recommended member for this board is:

1. MIROS : Malaysia Institute of Road Safety which represent the safety of road users.
2. JPJ : Road Transport Department to avoid fraud or crime related vehicles from being processed unknowingly.
3. Recyclers Association : represent recyclers.
4. Automobile Association Malaysia: represents the users interest in ELVR activity.
5. Sustainable Institute Malaysia: represents the environmental sustainability part, making sure all parties follow the environmental guidelines throughout the process.

4.2 ELV Fund Management

This body is responsible in managing fees related to ELV recycling system. They are required to provide monetary incentive for owners who wish to surrender their vehicle for scrapping. The fund management also model Taiwan system. Previously, the Malaysian government entrusted vehicle manufacturer for this fund (one-off incentive) but it's only limited to new vehicle purchase from that manufacturer only.

4.3 Sorting and Shredding Plant

Shredding and sorting plant is the new addition to Malaysian ELV recycling system. Failed parts are being sorted

according to its conditions. It may be remanufactured or recycled. Unrecyclable materials are originally sent to the landfill. This activity had increased the land usage that serves as dumping ground. The various sizes and shape of unrecyclable often breeding ground home by vectors such as vermin and mosquito. In the existing system, vehicles are being processed using blowtorch and metal saw to reduce the size. This activity is time consuming as well as unproductive. A dedicated shredding plant can increase this process and improve the sorting activities of the shredder dust by shredding it into small sizes. Valuable materials which are recyclable are being sorted by type and sent to respective recyclers. Automobile Shredder Residue (ASR) will be sent to ASR Incinerators.

4.4 ASR Incinerator Plant

Energy cannot be created or destroyed, but it can only be transferred. Energy used in producing the materials which are unrecyclable ASR can be extracted from its current condition via incineration. Incineration serves two purposes in ELV recycling system; to extract the energy and to reduce ASR weight. The by-product will be molten slag which can be used as brick or additional ingredient in concrete while the rest, if any will be sent to landfill.

5 CONCLUSION

This research project has presented the result of interviews conducted on Malaysian recycling companies with focus on ELV recyclers and part resellers. The main idea of the research is to provide a solution with win-win situation on the ever increasing number of ageing vehicle in Malaysia. It started with defining the current methodology of ELV management practice being applied in Malaysia. An interview had been done which involves 8 companies which consist of 5 recycling operators, 2 workshops, and 1 used tire reseller. Based on the information provided, a framework of current ELV recycling system had been developed. This framework was later sent to companies for validation which sees total acceptance which indicating the framework represents the real situation.

Rather than creating a framework from scratch, current practices and methodology successfully being applied in other countries such as Taiwan, China, Korea, Japan, Canada, and the European Union had been used in this research. It is followed by analysis of each system and a comparison between the key highlights was also done which saw most countries stated have governmental regulations except for Canada. It also includes, among other, the definition of an ELV by age by each country. This comparison also highlighted the most effective country, Taiwan to be the champion in ELV recycling with 95% of the vehicle initial weight being recycled. The strength of Taiwan ELV Recycling System or ELV Management was traced back to the foundation of an empowered ELV Management Board, which act as overseer for the whole process under the support from her government.

By compiling the advantages and covering any potential loopholes, a comprehensive framework had been developed which is an adaptation of ELV management success from around the globe. The Framework for ELV Recycling System in Malaysia will assist lawmakers and manufacturers for a better management of ELV in Malaysia before the problem becomes serious. It will also help the public to be more aware of their options regarding their vehicles.

6 ACKNOWLEDGMENTS

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