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End-of-Life Vehicles (ELVs) Management and Future Transformation in Malaysia

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ABSTRACT

As increasing global demand of vehicles and stringent environmental requirements are originating the most important waste flows from end-of-life vehicles (ELVs), their (ELVs') management has become an important research concern from the point of safe, economically, and environmentally sound manner. Malaysia is one of the raising automobile manufacturers, and its motorization rate is learnt to be increasing day by day. According to a report, more than five million cars on roads are aged between 10 to 15 years in Malaysia. The main problem being faced by the concerned authority is how to collect and manage the ELVs and what to do in order to obtain the maximum economic benefits from their recovery and at the same time fulfilling the relevant legislations. This paper presents the findings based on literature review, discussion with experts and academician on automobile use in Malaysia, ELVs management strategy, ELVs management system, sustainability consideration, and ELVs management limitations. It examines the current state of ELVs management from sustainable development of Malaysia's vehicle manufacturing and ELVs' reuse, remanufacture, and recycling industries. Findings suggest that more research on sustainable ELVs management to make a standard legislation for the Original Equipment Manufacturers (OEMs) and others (reuse, remanufacturing and recycling industries) to treat ELVs according to economic and environmental benefits.

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INTRODUCTION

Once a vehicle reaches its end-of-life and gets to be discarded, it is becoming an ELV. It has to be properly managed with the purpose of avoiding environmental pollution as well as recovering useful materials, especially metals. Firstly, fluids and other hazardous components, such as batteries are removed. Then, according to the market demand, components are dismantled and further reused, remanufactured or recycled. After these operations, hulks are baled and transported to a shredding plant where cars are reduced into pieces. The embodied materials are liberated and then sorted for recycling (Santini *et al*., 2011). End-of-life vehicles (ELVs) management in Malaysia has become a crucial issue in recent years owing to the impact of global warming, earthquakes, hurricanes, carbon footprint, and economic awareness. The production rate of local vehicles are increasing every year. That indicates the increasing rate of end-of-life vehicles (ELVs). Normally in Malaysia, vehicles are being used for extended periods. Vehicle manufacturers expected their vehicles to last for 15 years, hence vehicles exceeding this limit are considered as end-of-life Vehicle (ELV) (M. Azmi *et al*., 2010). A recent research finding shared by Malaysian Institute of Road Safety Research (MIROS) that cars older than 12 years are cited as "unsafe, unreliable and could be faulty" (Rahim, 2013). Putrajaya has revealed that there are more than 22 million vehicles on roads in Malaysia (Chang, 2013) with more than five million cars on roads are aged 10 to 15 years (Hoh, 2013). The auto industry contributed 3.2% of the country's gross domestic product in 2012, and is expected to increase to 10% in 2020. Now the National Automotive Policy (NAP) will focus on making the country an energy efficient vehicle (EEV) hub by 2020. Malaysia's EEV focus is not merely on fuel-efficient vehicles, but will encompass the whole auto green life cycle to improve their processes to reduce the impact on environment (Teng, 2013). Here the government would like to increase country's gross as well as energy efficient vehicles (EEV) to reduce the environmental impacts. So five million cars on roads are aged 10 to 15 years is a major issue need to be considered to manage it proper way. The government already introduced scrapping program, the proposed plan for scrapping of old cars have been scrapped altogether, replaced instead with a Voluntary Vehicle Inspection (VVI) policy. But this plan is still in development (T. Azmi, 2014). The

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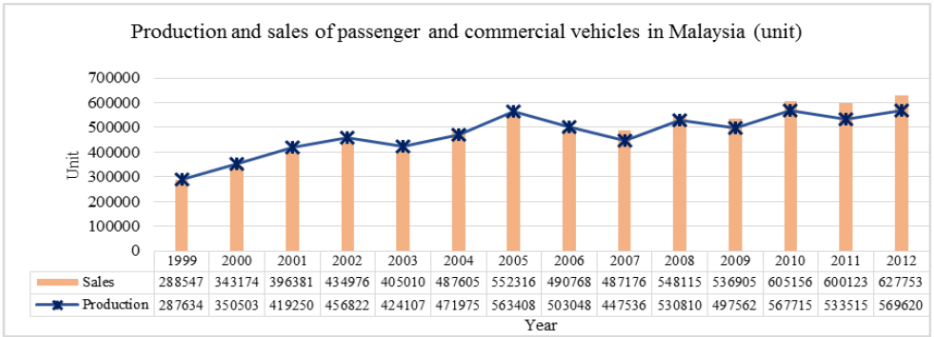
Malaysian government introduces a vehicle-scrappage subsidy as part of its 2-year, 60 billion ringgit ($16.4 billion) economic stimulus package. the government will finance 50% of the scrappage scheme, which pays owners of vehicles at least 10 years old MR5,000 ($1,354) to turn them in and purchase new cars from national auto makers Proton Holdings Bhd and Perusahaan Otomobil Kedua Sdn Bhd (Perodua). The auto makers will finance the other 50% (Harman, 2009). Even though government are trying to manage this ELVs around the country by making different policies and inspiring auto manufacture and consumer by giving different facilities but it's the time to make a standard policies for a proper solution of managing ELVs to sustain the environment and reduce human impact towards nature. The disposal of end-of-life vehicles (ELVs) is a 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 (M. Azmi *et al*., 2010). Kenné *et al*. (2012) shown while consumers traditionally dispose of products at the end of their life cycle, recovery of the used products may be economically more attractive than disposal (Kenné *et al*. 2012). Large environmental and economic benefits may be expected when applying an appropriate recovery strategy. A vehicle is a complex product consisting of a variety of materials (Harraz and Galal, 2011). ELVs metals account for up to 75% of a vehicle mass and, especially ferrous ones, are very easy and profitable to be sorted and thus to be recycled. On the contrary, the nonmetallic residue, called ''car fluff" or ''automobile shredder residue" (ASR), is mostly landfilled in many other European Countries, even though European Directive laws impose landfill reduction. Thus, fluff treatment and alternative management methods have been investigated in European countries (Santini *et al*., 2011). Increasing pressures and challenges to improve economic and environmental performance have caused developing countries in general and automobile manufacturing firms in particular to consider and start ELVs management. It is emerging as an important issue, which will not only reduce environmental degradation but also bring economic benefit to manufacturers (Lin *et al*., 2011). When a product reaches its EOL, there are a number of recovery options available such as reusing the product or its components, remanufacturing, material recycling, incineration and landfill (Mansour and Zarei, 2008). Based on extensive literature review, discussions with experts and some academicians this study identified the present status of automobile productions and sales, motorization rate , and existing conditions of ELVs management in Malaysia and worldwide ELVs management short description are represented to identified some ELVs management decision to minimize the environmental impacts and achieving economic benefits. The remaining part of the paper is organized as follows: section 1 provides a comprehensive automobile market and motorization rate in Malaysia. Section 2 presents the global ELVs management overview. Section 3 presents ELVs management future transformation and sustainable consideration for Malaysia, and section 4&5 presents the paper's main conclusions and acknowledgement.

1. Present automobile market status in Malaysia:

The automotive industry in Malaysia has developed since the establishment of Proton in 1985, followed by Perodua in 1993 as a part of the National Car Project. The introduction of the National Car Project has given a boost to the development of components and parts manufacturing in Malaysia. Currently, there are four local vehicle manufacturers, namely, Proton, Perodua, Naza, and Modenas.

1.1 Production and sales of passenger and commercial vehicles in Malaysia:

The rapid growth of the economy and the high purchasing power of its population have made Malaysia the largest passenger car market in ASEAN countries. At the same time, the establishment of national car projects, PROTON and PERODUA, has transformed Malaysia from a mere motor car assembler into a car manufacturer. Toyota, Honda, Nissan, Mercedes Benz, Volvo, BMW, Peugeot and Volkswagen are some of the global automotive companies, which have set up operations in Malaysia to take advantage of the buoyant consumer demand.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sales	288547	343174	396381	434976	405010	487605	552316	490768	487176	548115	536905	605156	600123	627753
Production	287634	350503	419250	456822	424107	471975	563408	503048	447536	530810	497562	567715	533515	569620

Fig. 1: Production and sales of passenger and commercial vehicles in Malaysia (MASI, 2013; MIDA, 2012).

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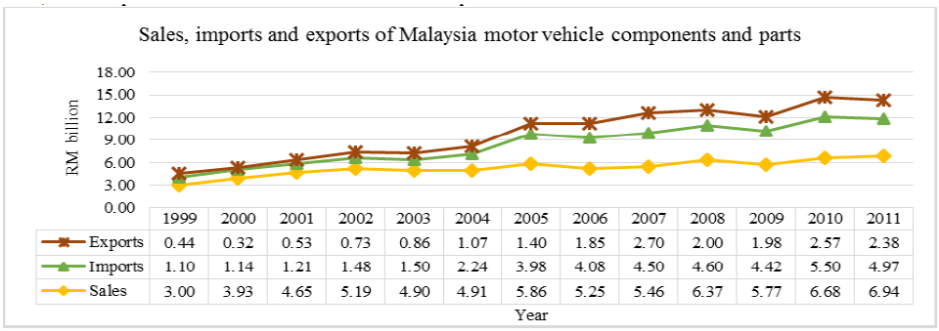
The vehicle production in Malaysia tends to increase due to the rapid increase in domestic sales. The total vehicle production in 2012 is 569,620 vehicles as compared to 287,634 vehicles in 1999. It manifests that the production rate of vehicles are increasing year by year (see Figure 1). The number of vehicles sold in the market has increased to 627,753 in 2012 as compared to 288,547 in 1999. Most of the vehicles sales in Malaysia is dominated by the local manufacturers. Currently, there are 28 manufacturing and assembly plants producing passenger and commercial vehicles, composite body sports cars as well as motorcycles and scooters. These plants have a total installed capacity of approximately 963,300 passenger and commercial vehicles and about 1 million motorcycles per year, with production catering primarily for the domestic market.

1.2 Sales, imports and exports of Malaysia motor vehicle components and parts:

The development of Malaysia's automotive industry has made the country a production center for major automotive component manufacturers. Today, there are more than 800 automotive component manufacturers. The establishment of local OEMs and international component manufacturers' leads to an increase in the number of components or parts manufacturers such as TRW, Delphi, Continental, Nippon Wiper Blade, Denso and Bosch. They are producing a wide range of components, such as body panels, brake parts, engine parts, transmission and steering parts, rubber parts and electrical and electronic parts. In 2011 (Figure 2), the sub-sector generated sales of RM 6.94 billion, while imports amounted to RM 4.97 billion and exports RM 2.38 billion.

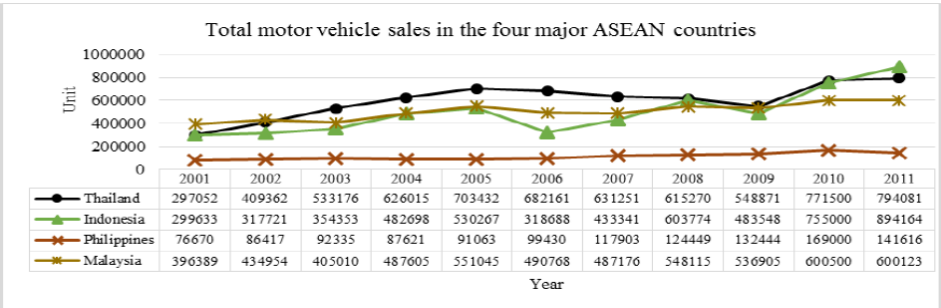


	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Exports	0.44	0.32	0.53	0.73	0.86	1.07	1.40	1.85	2.70	2.00	1.98	2.57	2.38
Imports	1.10	1.14	1.21	1.48	1.50	2.24	3.98	4.08	4.50	4.60	4.42	5.50	4.97
Sales	3.00	3.93	4.65	5.19	4.90	4.91	5.86	5.25	5.46	6.37	5.77	6.68	6.94

Fig. 2: Sales, imports and exports of Malaysia motor vehicle components and parts (MIDA, 2012).

1.3 Total motor vehicle sales in the four major ASEAN countries:

Pragmatic government policies, political and economic stability, sound economic fundamentals, well developed infrastructural facilities and an educated and skilled labour force have attracted major international automotive and component manufacturers to invest in Malaysia. Total motor vehicle sales in the four major ASEAN countries graph (Figure 3) shown that Malaysia's sales rate are increasing between years 2007 and 2011.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Thailand	297052	409362	533176	626015	703432	682161	631251	615270	548871	771500	794081
Indonesia	299633	317721	354353	482698	530267	318688	433341	603774	483548	755000	894164
Philippines	76670	86417	92335	87621	91063	99430	117903	124449	132444	169000	141616
Malaysia	396389	434954	405010	487605	551045	490768	487176	548115	536905	600500	600123

Fig. 3: Total motor vehicle sales in the four major ASEAN countries (MIDA, 2012).

1.4 World motorization rate in 2011:

According to world motorization rate in 2011 (Figure 4) shown that world average motorization rate is 165 where Malaysian's motorization is higher than (379 units per thousand people) Thailand, Turkey, Russia, Mexico and China.

With a ratio of 379 cars for every one thousand people, Malaysia ranks among countries with high car ownership ratio in the ASEAN region and motorization rate is increasing from 2004 to 2011 (Figure 5).

The motorization rate in Malaysia tends to increase due to the rapid increase in domestic sales, cheap price of vehicles, friendly governmental policies and less or zero interest of vehicles buying policies. The motorization rate in 2011 is 379 vehicles as compared to 272 vehicles in 2003.

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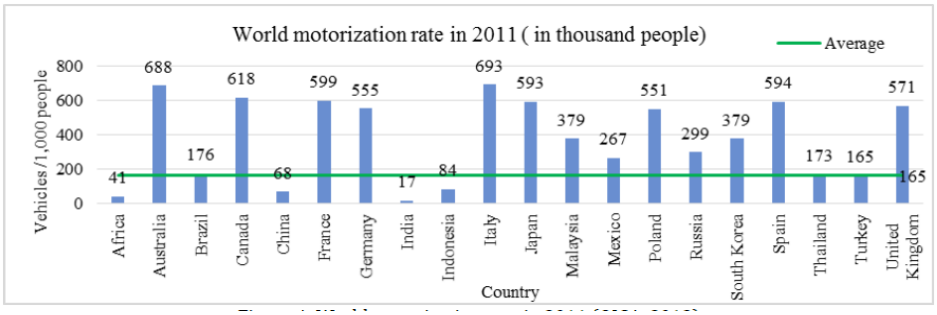

Fig. 4: World motorization rate in 2011 (OICA, 2013).

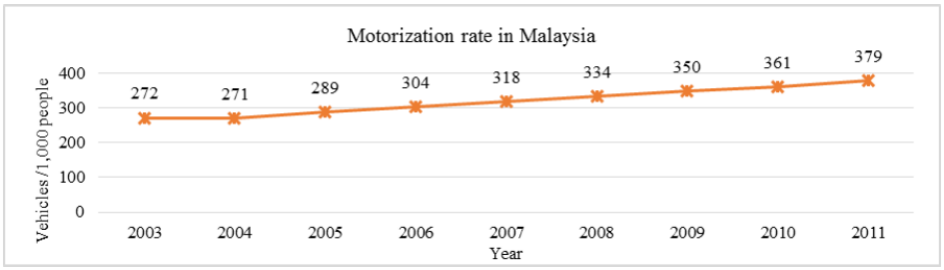

Fig. 5: Motorization rate in Malaysia (OICA, 2013; TWB, 2013).

2 Global ELVs management overview:

Environmental concern as well as government legislation has motivated manufacturers in many countries to consider product life cycle issues and deal with product recovery at the end of the product life cycle. The automotive industry is one of the leading industries in this environmentally conscious manufacturing and product recovery. End-of-life vehicles (ELVs) represent one of the most important waste flows in Japan and 3.58 million was processed only in fiscal year 2008. In an attempt to reduce waste originating from ELVs, the Japanese Government introduced the ELV Recycling Law in 2002 (Simic and Dimitrijevic, 2013). In the USA, 95% of cars and trucks that are retired each year go to the recycler, and for each of those cars, 75% by weight is recovered for reuse (Gungor and Gupta, 1999). In the European Union (EU) countries, the European Union end-of-life vehicles (ELVs) Directive has passed laws to the member countries to reuse and recover 85% by weight of the average vehicle by the year 2006, and this percentage will increase to 95% by the year 2015 (Amelia *et al*., 2009; Kojima and Damanhuri, 2009). By 2015, the EU directives required the automobile manufacturers to produce a vehicle that contains reusable and / or recoverable parts at least 95% of total weight. In the developed countries, the legislative issue such as the take-back policy, which requires the manufacturers to consider the end-of-life (EOL) of their products at early design stage (Ghazalli and MURATA, 2008). The implementation of the directive seems to be successful in accelerating the environmental sustainability in EU countries. As shown in Table 1, in 2011 the average of recycling and reuse rate in EU countries achieves 84.55%, which is almost achieving the target (85%) and the average recovery and reuse rate is 89.74%, which is higher than the target. According to recycling and reuse rate twelve countries met the targets including Belgium, Bulgaria, Denmark, Germany, Greece, Italy, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. Another important issue is that according to recovery and reuse rate there are twenty six countries meet the target where fourteen countries met more than 90%. Those are Austria, Belgium, Bulgaria, Denmark, Finland, Germany, Liechtenstein, Luxembourg, Netherlands, Norway, Poland, Slovakia, Slovenia, and Sweden.

The European Union (EU), Japan, Korea and Taiwan present examples of countries having a product-oriented legislation has been initiated to control the recovery of end-of-life vehicles (ELVs). In the EU the automotive recycling industry exists as a profitable industry since 1950s. The need for environmental legislation was driven by the concern of the ever shrinking landfill capacities. About 8–9 million ELVs per year are estimated to be recycled in the EU countries. The Directive 2000/53/EC has been adopted. In Japan, the ELV Recycling Law came into force in 2005 to deal with an estimated value of 5 million ELVs produced annually need to collect and recycle. Korea issued the Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles on April 2, 2007. The act came into force as from 1 January 2008 to manage Korean ELVs for recycle, and part reuse. Taiwan is a further example of a country establishing an ELV management system. Prior to 1994, the recycling of ELVs in Taiwan was performed by related operators in the industry. Since the publishing of the ‘‘End-of-life vehicle recycling guidelines’’ under the authority of the Waste Disposal Act by the Environmental Protection Administration (EPA) in 1994, the recycling of ELVs in Taiwan has gradually become systematic (Harraz and Galal, 2011). A short comparison of ELVs management system between different countries are given below (Table 2).

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Table 1: End-of-life vehicles-recovery rate in European Union countries in 2011 (Eurostat, 2013).

Country	Total recycling and reuse %	Total recovery and reuse %	Country	Total recycling and reuse %	Total recovery and reuse %
Austria	82.8	97.6	Liechtenstein	80	92.4
Belgium	88.2	90.6	Lithuania	87.2	87.4
Bulgaria	90	92	Luxembourg	83	91
Cyprus	84	86.6	Malta	87	87.1
Czech Republic	80.3	86.3	Netherlands	83.1	96.2
Denmark	92.8	92.9	Norway	73.6	93.3
Estonia	76.1	79	Poland	89.5	91.5
Finland	82.5	95	Portugal	82.9	87.9
France	80.8	84.8	Romania	82.9	86.8
Germany	93.4	108.2	Slovakia	93.1	94.6
Greece	85.2	87.7	Slovenia	86.1	90.3
Hungary	84.4	86.2	Spain	82.9	87.4
Iceland	82	82	Sweden	84.4	90.8
Italy	84.8	85.3	United Kingdom	83.4	85.6
Latvia	85.4	86	Average:	84.55%	89.74%

Table 2: Comparison of ELV management system between countries (M. Azmi *et al*., 2010).

Details	Taiwan	China	Korea	Japan	Canada	Singapore	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
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	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

End-of-life vehicle recycling in Malaysia however is being done by 5,000 small companies bound under associations such as Malaysia Automotive Recyclers Association (MAARA) and working without a standard working practice. 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 ELVs (M. Azmi *et al*., 2010).

3 ELVs management and future transformation for Malaysia:

The treatment of end-of-life vehicles (ELVs) and the environmental impact of discarding the resulting residues are subjects of worldwide concern. As the automotive industry develops, its impact to the environment also increases. Average range of vehicles life is considered between 10 and 15 years, after that they will enter the retired phase. The issues are how to deal with the wastes from retired vehicles and how to get economic and environmental advantage from it. Malaysia produced around 1,103,457metric tonnes of hazardous waste in 2006. The Department of Environment has identified 77 categories of scheduled wastes, which primarily come from the chemical, automotive, workshop, petrochemical, metal, and pharmaceutical industries (Amelia *et al*., 2009). Even if the local end-of-life vehicle-recovery directive has not been established, the economic benefit of ELVs recovery should motivate the local automotive manufacturers. In other countries, some vehicle manufacturers have developed end-of-life recovery program such as reuse, remanufacturing, and recycling. According to literature review of different journals (Table 3) on ELVs management, author would like to represent possible options to think for future transformation of ELVs to introduce ELVs Directive for Malaysia like EU to increase recovery rate up to 95%, of which a minimum of 85% will have to be reusable and recyclable material. There are six possible management options are highlighted below where the “recover / disposal and landfill” options are considered as closing option for all end-of-life products.

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i. Reuse: Reuse is the highest hierarchy in product recovery. Reuse materials/ components/ products after its first life-cycle in subsequent life-cycles of the same product or in other applications, in an effort to reduce the use of new (virgin) raw materials to produce such materials/ components/ products.
ii. Repairing: Repairing is simply the correction of specified faults in a product. Generally, the quality of repaired products is inferior to those of remanufactured and reconditioned alternatives. When repaired products have warranties, they are less than those of newly manufactured equivalents. Also, the warranty may not cover the whole product but only the replaced component.
iii. Reconditioning: Reconditioning involves less work content than remanufacturing, but more than that of repairing. This is because reconditioning usually requires the rebuilding of major components to a working condition that is generally expected to be inferior to that of the original model.

Table 3: Possible ELVs management options.

ELVs Management	Amelia et al. (2009)	Go et al. (2011)	Mat Saman and Blount (2006)	Santini et al. (2011)	Gerner* et al. (2005)	Gerrard and Kandlikar (2007)	Ferguson and Browne (2001)	Bellmann and Khare (2000)	K.-c. Chen et al. (2010)	M. Chen and Zhang (2009)
Reuse	√	√	√	√	√	√	√		√	√
Repair	√	√			√	√	√	√		
Reconditioning	√	√	√			√	√			
Remanufacture	√	√	√	√		√	√	√		√
Recycling	√	√	√	√	√	√	√		√	√
Incineration & Landfill	√	√	√	√	√	√	√	√	√	√

iv Remanufacturing: Remanufacturing is the only process where used products are brought at least to OEMs performance specification from the customer's perspective and, at the same time, are given warranties that are equal to those of equivalent new products. This is because remanufacturing requires the total dismantling of the product and the restoration and replacement of its components.
v. Recycling: Recycling is "the series of activities by which discarded materials are collected, sorted, processed, and used in the production of new products". Process of converting end-of-life materials (that would otherwise be considered waste) into new material/ product for use when another recovery options are not possible.
vi. Recover / disposal and landfill: Recovery is the use of waste for useful purposes such as energy recovery, road surfacing etc. Incineration is a disposal method in which solid organic wastes are subjected to combustion so as to convert them into residue and gaseous products. Then, the last consideration is a waste material that is sent for disposal in landfill.

3.1 Sustainability consideration during of ELVs management:

Sustainability has become an important issue in all spheres of life. This will be the case for many years to come, or at least until we find an as yet unknown solution. Sustainability focuses on safeguarding natural resources against exploitation, in the name of productivity and competitiveness, by manufacturing and service organizations. It is a major concern in many countries and is leading to strict regulations regarding the impact of products and services during their manufacturing, use and end of life. Companies around the world have shown interest in environmentally friendly manufacturing. Presently, the focus is on end-of-life (EOL) product recovery which is different from traditional focus in terms of pollution control and life-cycle assessment. Products and processes interact with the environment and create a chain reaction effect on environmental pollution. Companies have been under increasing pressure to seriously think about their sustainable business practices both in manufacturing and end-of-life (EOL) product management. ELVs management business is profitable as well as its contribution for environmental impact need to think. From the various research they have shown that ELVs management is important to minimize the environmental impacts and wastes. So sustainable ELVs management is the major concern right now. Malaysia has a lots of opportunity to explore sustainable ELVs management business to gain maximum profit and minimize wastes all over the country. There are some sustainable business criteria that are given below for sustainable consideration during ELVs management decision making.
i. Economic: In order to enhance the ELVs management, economic value of the automotive components has been a major concern. In the chain of end-of-life, except for landfill and incineration, components of economic value destined for reuse, remanufacture, or recycling of end-of-life vehicles. The main sustainable ELVs management business economic criteria are profit (direct benefit- the profit gained, indirect benefit- the potential business opportunities/ markets explored), cost savings (fixed cost, collection cost, operating cost, testing cost, installation cost, quality cost, and marketing cost), and resource utilization (energy used, technology used, raw material used, chemical used)
ii. Environmental: Environmental sustainability has become the main items of contest in the automotive industries. Therefore in the order to reduce the environmental impact of end-of-life vehicles, European Union, Japan, USA, and Australia laws require manufacturers to take back their products at the end of their useful life

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and recycle them (Go *et al*., 2011). The environmental sustainability criteria are natural resource use, pollution prevention like air pollution (e.g. CO2, NOX, SOX, and dust), water pollution, land pollution and waste. For environmental management require to setup environmental goals, environmental management systems for reduction of pollutions, emissions, and resource use.

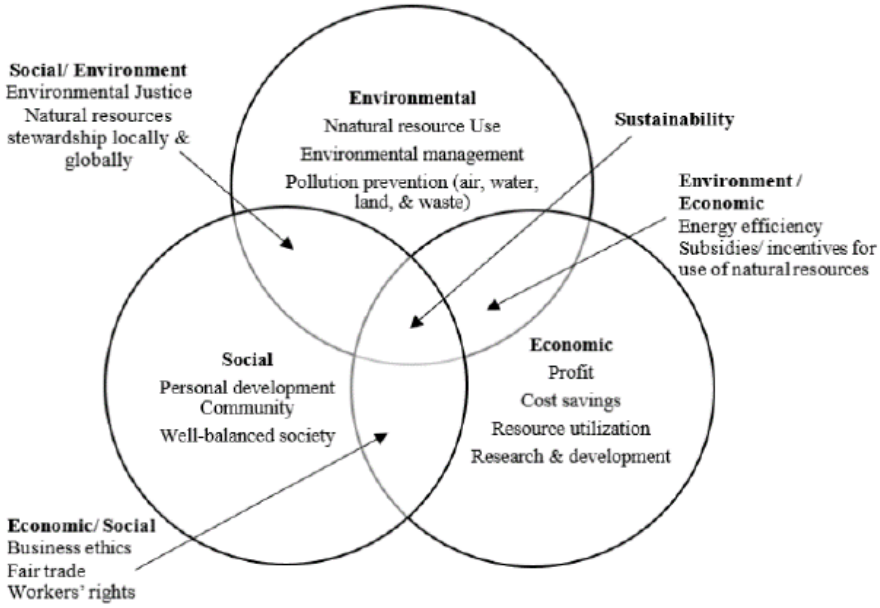

Fig. 6: Sustainable business criteria.

iii. Social: The social impacts should be consider during ELVs management, even though now most of the people focused on environmental effects (e.g. human health) on culture and upon the society. Health and safety at workplace, public acceptability, corporate reputation, social impact, ecological risk, safety risk, and brand image etc. are the major consideration for sustainable ELVs business. The social sustainability criteria are personal development (healthy life, sufficient food, sufficient to drink, safe sanitation, education opportunities and gender equality), clean environment (air quality, surface water quality and land quality), well-balanced society (good governance, unemployment, population growth, income distribution and public debt), public acceptability, and corporate reputation.

Figure 7 shown the summarized vehicles production chain and ELVs future transformation. It's also highlighted the sustainable business opportunities in ELVs management for OEMs and ELVs management organization. The reuse, remanufacturing and recycling of products or parts is the most significant in terms of resource conservation and in economic terms.

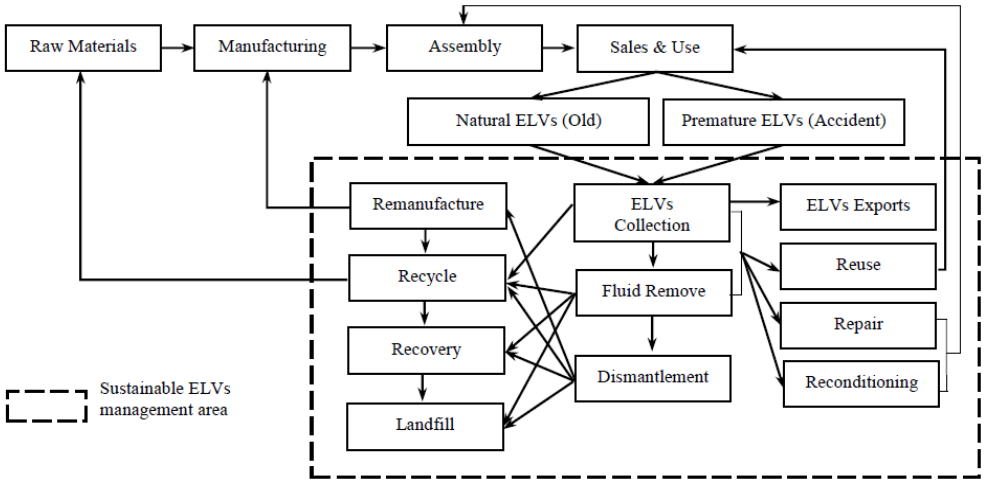

Fig. 7: Summarized ELVs management options and sustainable business area.

RESULT AND DISCUSSION

An end-of-life vehicle (ELV) is a specified vehicle which is discarded or is to be discarded by its registered owner as waste. Vehicles normally reach the end of their useful lives, either due to age (typically around 12-14

years), or because of heavy damage following an accident. Therefore there is no fixed age, at which a vehicle can be considered an end-of-life vehicle. Malaysian automobile and component parts productions / sales and motorization rate shown that country need to think and implement a master plan for ELVs management otherwise they will face a serious automobile waste problem. A new record of vehicle sales has been achieved in 2012 (Figure 1) in Malaysia. The quick development of the vehicle industry also leads to energy consumption, environmental degradation, ecological destruction, and other issues, hence hindering the sustainable development of Malaysia. Consequently, it has become increasingly important for the vehicle industry to confront these issues. According to end-of-life vehicles-recovery rate in European Union countries in 2011 (Table 1) shown that every Europeans country giving effort to minimize the waste and gaining profit by remanufacturing, reusing and recycling of ELVs. As a developing country, Malaysia exerts efforts to learn from developed countries by promoting sustainable development in its vehicle industry in line with present conditions.

4.1 ELVs future transformation or management scope in Malaysia:

The current vehicle recovery (reuse, remanufacture and recycle) industry is still in its infancy, which makes the introduction of extended producer responsibility (EPR) inevitable in Malaysia. So it requires to develop Malaysia's ELVs recovery policies based on EPR and discusses the recycling system in line with the country's actual conditions. Now there have a short discussion on reuse, remanufacture and recycling business potential of ELVs in Malaysia for ELVs management decision making.

i. Automobile reuse business-potential in Malaysia

There is no exact figure available to describe the number of ELVs that have been recovered in Malaysia. It seems very small as compared to the total number of recovered and recycled materials in Malaysia that is just around 5% of the total waste disposed (Amelia *et al*., 2009). From the literature and expert decision it's almost clear that reuse of ELVs will reduce consumer satisfaction due to old parts use, but it's also true that the company will be benefited from reuse in terms of reducing cost, ensuring availability of components, and reducing environmental impacts. The only motive that drives local OEMs to develop reused parts–components is to ensure the supply of spare parts for older vehicles.

ii. Automobile remanufacturing business-potential in Malaysia

Popular in Europe and the USA, and currently in Japan**.** Auto parts are the most prevalent target of remanufacturing in the world. Up to two-thirds of remanufacturing businesses globally is estimated to involve auto parts**.** Auto parts remanufacturing saves material and energy. A new part requires about 9 times more material and 7 times more energy (MAI, 2011)**.** The remanufactured auto parts primarily include engines, turbo chargers, alternators, starters, compressors, transmissions, and steering units. Some automotive remanufacturing companies have been established in Malaysia and produced remanufactured parts–components such as alternators, starters, air conditioning compressors, batteries, exhaust system, and body parts. ELVs and its parts remanufacturing also require to lunch broadly to support the local customers. This approach will reduce importing cost, transportation costs for shipping and will reduce the lead-time required to provide remanufactured products to customers.

iii. Automotive recycling business-potential in Malaysia

Vehicles are one of the critical products causing a considerable environmental burden during the phases of usage and disposal. A vehicle is a complex product consisting of a variety of materials (Table 4). The estimated composition of ferrous material is the major component of a ELVs accounting for 68% of a vehicle's weight. Other major materials included in the vehicle are plastics, non-ferrous metals, rubber, glass and fluids contributing to 10%, 8%, 2%, 3%, and 2%, respectively (Sujith Kollamthodi, 2003).

Table 4: Parts recycled from ELVs (Go *et al*., 2011).

Part	Recycled	Part	Recycled
Window (glass)	Tiles etc.	Radiators (copper and aluminium)	Gun metal ingots and aluminium products
Seat (foam and fiber)	Soundproofing materials for vehicles	Coolant, Engine and gear oil (oil)	Alternative fuel for boilers and incinerators
Body, trunk, hood and door (steel)	Car parts and general steel products	Engine, transmission, suspension and wheel (steel and aluminium)	General steel and aluminium products
Wire harness (copper)	Copper and engines products (cast aluminium reinforcement)	Catalytic converter (rare metals)	Catalytic converters
Bumper (resin)	Bumper, interior parts, toolbox etc.	Tyre (rubber)	Raw material and alternative fuel for cement manufacture

To recovery the valuable materials and reducing the ELVs waste, some recycling industries are established in Malaysia but now it's a time to think about standard ELVs management directive for proper monitoring and exploring this kind of industries.

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4.2 ELVs management limitation and consideration:

There are several reasons reuse, remanufacture and recycling can fail the business case, such as the high investment costs for establishing reverse logistics network or the cost of the quality assurance test equipment or due to the fact that the product was not designed to be disassemble easily for reuse, remanufacture or recycle. There are three main limitations and considerations are discussed here-

Core collection / reduce ELVs direct sales to the open market

An effective core management process is the backbone of ELVs management programs. A product exchange process is a typical way of making cores available for the Original Equipment Service (OES) team. In this process, the dealership collects the returned cores from the end consumer and sends them to the OE supplier. As a developing country, automobiles are rather expensive in Malaysia. In addition, scrapping allowance is very minimal. This means that many vehicle owners do not discard their vehicles when the government-set lifetime has expired. Many of these vehicles (i.e., those that should have been scrapped, as per government requirement) are instead sold to poor areas or to the second-hand market. More seriously, authorities do not monitor these activities. This yields problems with illegally reassembled cars, overtime service, and lack of service record, among others. So ELVs reuse, remanufacture and recycling industries are not getting cores as much as they forecast, this focal point needs to be improved immediately.

ii. Design for reuse, remanufacture and recycle

The efficiency and effectiveness of the ELVs management process can also greatly depend upon how the product has been designed (factors within the designers' control): features such as fastening and joining methods, product architecture, and material choice can have an effect upon ease of disassembly, ease of reprocessing, and so on. So OEMs require to consider designing factors as much as they can during product design to ensure the below objectives-

o To reduce the use of hazardous substances when designing vehicles,
o Design and produce vehicles which facilitate the easy dismantling for reuse, remanufacturing, and recycling,
o Increase the use of recycled materials and avoid unnecessary components in vehicles, and
o Vehicle components placed on the market do not contain mercury, hexavalent chromium, cadmium, or lead.

iii. Technologies and testing equipment

Technological issues are quite important to improve the rates of reuse, remanufacture, recycling, and recovery of ELV components and materials, aiming to realize the target recoverability rates of automobile products. According to the provisions of ELVs product recovery technology policy in Malaysia, dismantlability of ELVs must be taken into account during the design and production of new vehicles for high resource utilization and that generate less waste and facilitate the recovery of ELVs.

4.3 Governmental ELVs management directive:

According to market demand information automotive industry is expanding and producing more than 500,000 vehicles every year in Malaysia, the burden to environment also increases. So ELVs directive is apparently needed and should be established by the local government. This directive will force the automotive manufacturers to deal with environmental problems and development of the ELVs recovery programs such as reuse, remanufacturing, and recycling. It is also important to acknowledge that government already taken lots of long term strategic plan for ELVs management. The following proposals may be included during their future plan.

o Require to introduce practical ELVs Recycling Law for automobile manufacturers and importers to collect and recover air bags, chlorofluorocarbons/hydro fluorocarbons (CFCs/HFCs) and automobile shredder residue (ASR) generated during the process of recycling ELVs to reduce waste originating from ELVs.
o Voluntary periodical vehicles inspection, deregistered at the government authority, license authorized treatment facilities, owner receive certificate of destruction.
o Legislation nurturing the auto-remanufacturing industry should be established. The government may support investment stimulus. For example, the investment tax reduction on environmental conservation facilities shall be implemented. Create a conducive environment to attract new investment and expand the existing opportunities.
o Responsible research organization shall be established to support remanufacturing technologies, design for reuse, remanufacture and recycling.
o Collaboration among government agencies and local authorities. Willingness and support from Malaysia Automotive Recyclers Association (MAARA), Federation of Automobile Workshop Owners' Association of Malaysia (FAWOAM), National Automotive Workshop Administration Malaysia (NAWAM), The National Automotive Policy (NAP), Malaysia Automotive Industry (MIDA), Malaysia Automotive Institute (MAI) and other related associations.

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REFERENCES

Amelia, L., D. Wahab, Che C. Haron, N. Muhamad, C. Azhari, 2009. Initiating automotive component reuse in Malaysia. *Journal of Cleaner Production, 17*(17): 1572-1579.

Azmi, M., M.Z.M. Saman, S. Sharif, N. Zakuan, S. Mahmood, 2010. 5.6 Proposed framework for End-Of-Life vehicle recycling system implementation in Malaysia.

Azmi, T., 2014. NAP 2014. *The Sun Daily (30 January 2014), http://www.thesundaily.my/node/239493* (Accessed on 21 February 2014).

Bellmann, K., A. Khare, 2000. Economic issues in recycling end-of-life vehicles. *Technovation, 20*(12): 677-690.

Chang, T., 2013. The 12 years cap on lifespan of cars in Malaysia has been scrapped,for now. *autofreaks.net, http://www.autofreaks.net/2013/11/the-12-years-cap-on-lifespan-of-cars-in-malaysia-has-been-scrapped-for-now/* (November 21, 2013).

Chen, K.C., S.H. Huang, I.W. Lian, 2010. The development and prospects of the end-of-life vehicle recycling system in Taiwan. *Waste management, 30*(8): 1661-1669.

Chen, M., F. Zhang, 2009. End-of-life vehicle recovery in China: consideration and innovation following the EU ELV directive. *JOM, 61*(3): 45-52.

Eurostat, 2013. End-of-life vehicles: Reuse, recycling and recovery. *EU Environmental Data Centre on Waste (Eurostat);*(Accessed on 09 December 2013).

Ferguson, N., J. Browne, 2001. Issues in end-of-life product recovery and reverse logistics. *Production Planning & Control, 12*(5): 534-547.

Gerner, S., A. Kobeissi, B. David, Z. Binder, B. Descotes-Genon, 2005. Integrated approach for disassembly processes generation and recycling evaluation of an end-of-life product. *International Journal of Production Research, 43*(1): 195-222.

Gerrard, J., M. Kandlikar, 2007. Is European end-of-life vehicle legislation living up to expectations? Assessing the impact of the ELV Directive on 'green'innovation and vehicle recovery. *Journal of Cleaner Production, 15*(1): 17-27.

Ghazalli, Z., A. Murata, 2008. Development of the evaluation system for automobile remanufacturing.

Go, T., D. Wahab, M.A. Rahman, R. Ramli, C. Azhari, 2011. Disassemblability of end-of-life vehicle: a critical review of evaluation methods. *Journal of Cleaner Production, 19*(13): 1536-1546.

Gungor, A., S.M. Gupta, 1999. Issues in environmentally conscious manufacturing and product recovery: a survey. *Computers & Industrial Engineering, 36*(4), 811-853. doi: http://dx.doi.org/10.1016/S0360-8352(99)00167-9.

Harman, A., 2009. Malaysia Launches Scrappage Subsidy to Aid Struggling Auto Industry. *Wardsauto.com, http://wardsauto.com/ar/malaysia_scrappage_subsidy_090316* (Mar. 16, 2009).

Harraz, N.A., N.M. Galal, 2011. Design of Sustainable End-of-life Vehicle recovery network in Egypt. *Ain Shams Engineering Journal, 2*(3): 211-219.

Hoh, K.S., 2013. ELV likely to be re-introduced. *The Sun Daily (7 November 2013), http://www.thesundaily.my/news/876313* (Accessed on 21 February 2014).

Kenné, J.P., P. Dejax, A. Gharbi, 2012. Production planning of a hybrid manufacturing–remanufacturing system under uncertainty within a closed-loop supply chain. *International Journal of Production Economics, 135*(1): 81-93.

Kojima, M., E. Damanhuri, 2009. 3R Policies for Southeast and East Asia. *ERIA Research Project Report*(10).

Lin, R.J., R.H. Chen, T.H. Nguyen, 2011. Green supply chain management performance in automobile manufacturing industry under uncertainty. *Procedia-Social and Behavioral Sciences, 25:* 233-245.

MAI., 2011. Towards a Sustainable Malaysian Automotive Recycling Industry. *4th Asian Automotive Environmental Forum, Presented by Malaysia Automotive Institute (MAI)*(Accessed on 21 February 2014).

Mansour, S., M. Zarei, 2008. A multi-period reverse logistics optimisation model for end-of-life vehicles recovery based on EU Directive. *International Journal of Computer Integrated Manufacturing, 21*(7): 764-777.

MASI., 2013. Summary of Sales & Production Data. *Malaysia Automative Sale Info (http://www.maa.org.my/info_summary.htm) ;* (Accessed on 05 December 2013).

Mat Saman, M.Z., G.N. Blount, 2006. End of life vehicles recovery: process descriptio, its impact and direction of research. *Jurnal Mekanikal,* 21: 40-52.

MIDA, 2012. Business opportunities- Malaysia's Automotive Industry. *Transport Industry Division, Malaysian Investment Development Authority (MIDA)*(www.mida.gov.my).

OICA., 2013. Automobiles sales & production statiscics data. *The International Organization of Motor Vehicle Manufacturers (Organisation Internationale des Constructeurs d'Automobiles) http://www.oica.net/category/about-us/* (Accessed on 09 December 2013).

Rahim, M., 2013. To scrap, or not to scrap? *The Malaysian Insider (19 November 2013), http://www.themalaysianinsider.com/sideviews/article/to-scrap-or-not-to-scrap-adit-rahim* (Accessed on 21 February 2014).

Santini, A., L. Morselli, F. Passarini, I. Vassura, Di S. Carlo, F. Bonino, 2011. End-of-Life Vehicles management: Italian material and energy recovery efficiency. *Waste management, 31*(3): 489-494.

Simic, V., B. Dimitrijevic, 2013. Modelling of automobile shredder residue recycling in the Japanese legislative context. *Expert Systems with Applications, 40*(18), 7159-7167. doi: http://dx.doi.org/10.1016/j.eswa.2013.06.075.

Sujith Kollamthodi, K.J.a.L.E., 2003. To Assess the Data Collection and Quantification Involved with Demonstrating Compliance with the End of Life Vehicles Directive. *Department for the Environment, Food and Rural Affairs (DEFRA), UK*.

Teng, L.J., 2013. Govt to announce revised auto policy in mid-January. *The Sun Daily (13 November 2013), http://www.thesundaily.my/news/880074* (Accessed on 21 February 2014).

TWB, 2013. Motor vehicles per thousand people. *The World Bank (http://data.worldbank.org/indicator/IS.VEH.NVEH.P3?page=1)*, Accessed on 10 December 2013.