

END-OF-LIFE VEHICLES MANAGEMENT AND INITIAL ESTIMATION OF THE MATERIAL FLOW FROM ELV IN VIET NAM

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Received: 1 July 2020; Accepted for publication: 21 September 2020

Abstract. End-of-life vehicles (ELV) can be considered one of the many scrap sources in Viet Nam that is out of the Government's control. This initial research in Viet Nam was conducted for the estimation of ELV flow and the determination of material flow from an ELV. For the estimation of ELV in Viet Nam, a combination of the population balance model, logistic function and Weibull distribution is used. It is estimated that the ownership rate of cars in households will quickly increase, and thus, increases the number of total cars and ELV. By 2030, the ownership rate in household will reach 0.062 unit per household, which is twice the figures in 2017 and 10 times the rate in 2010; and nearly 60,000 passenger cars will be discarded. In the case of a common passenger car, it was found out that more than a half of an ELV (57 %, in weight) can be reused in Viet Nam, including mostly engine parts, wheels, air bags, speakers, chassis or mirrors. About one third (32 %) can be recycled as secondary material resources, including mainly metal parts and some types of plastic and rubber. The rest (11 %) that cannot be reused or recycled is dumped without control around the dismantling site, harming the environment and public health. While ELV is classified into groups of equipment that are required to be retrieved and treated by their producers under Decision 16/2015/QĐ-TTg, Viet Nam currently does not have any proper legislation to control this waste flow, as well as any formal facility to treat it. Thus, it is quite challenging for the Vietnamese Government to improve the regulations and management infrastructure for the application of Extended Producer Responsibility system to manage this type of waste.

Keywords: End-of-Life vehicles, material flow, extended producer responsibility, Viet Nam, waste inventory.

Classification numbers: 3.3.2, 3.8.3.

1. INTRODUCTION

End-of-Life Vehicles (ELVs) can be defined as any type of automotive that are discarded, intended to discard or are required to discard, which include (1) outdated vehicles or deregistered vehicles, (2) broken vehicles, and (3) unused vehicles that will eventually become outdated. The socio-economic development of Viet Nam caused the increase of the number of

vehicles, and thus, rose the number of ELV as a major source of waste. The waste flow from ELVs has now become a serious world-wide concern [1, 2, 3], due to its rapidly increasing quantity, the volume of secondary materials such as metal, plastic, rubber, and glasses, as well as the content of many hazardous substances that causes serious problem for the environment and human health if it is not put under a proper management system [1, 4].

According to Vietnam Registration Administration (VRA), up to February 2020, Viet Nam has 3,553,700 registered vehicles. The number of registered vehicles in December 2016 was 2,516,144, showing the increased rate of 0.913 %/month and approximately 11 %/year. On the other hand, each year, there are tens of thousands of vehicles that come to end of life that is not allowed to transport and should be collected and treated. As of 2020, there are about 222,860 outdated vehicles (170,093 trucks/vans and 52,767 passenger cars/buses) that are required to be taken back and treated as waste and hazardous waste under the supervision of reliable government agencies. From 2015, the number is fluctuating around 15,000 – 20,000 vehicles every year as shown in Figure 1 and will continue to rise alongside the number of registered vehicles.

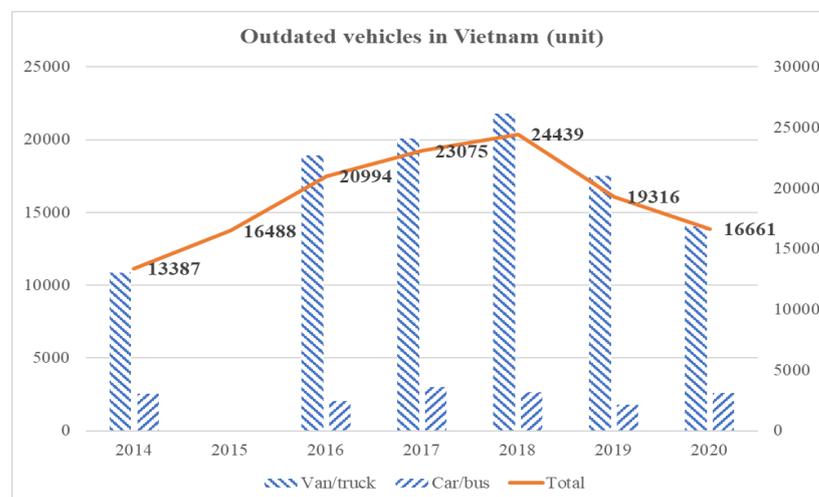


Figure 1. Number of outdated vehicles in Viet Nam in 2014 – 2020.

Currently, only the number of outdated passenger cars/buses and trucks/vans are yearly reported by the VRA, as seen in Fig. 1. It is because of that only these aforementioned types of vehicles have their lifespan regulated as provided by the Decree No. 95/2009/ND-CP (Article 4) [5], which is guided by the Circular 21/2010/TT/BGTVT (Article 6) [6]. According to these regulations, a freight carrying car has a lifespan of 25 years, and the lifespan of a passenger car above 10 seats is 20 years. These reported numbers are based on the registered date and lifespan of vehicles. However, there is no any official data on the number of discarded passenger cars that are less than 10 seats.

Considering that ELV are required to be withdrawn and treated by the producer as prescribed in the Decision 16/2015/QĐ-TTg, effective since May 22, 2015, of the Prime Minister prescribing retrieval and treatment of discarded products [7] (that replaced the Decision 50/2013/QĐ-TTg, dated August 09, 2013, regarding the prescribed withdrawal and processing of discarded products [8]). These decisions are the most fundamental legislation for the application of the Extended Producer Responsibility (EPR) system for discarded products, including ELV and batteries [9]. Nevertheless, up to present, there is no other legislation related

to the responsibility of retrieval and treatment of ELV in Viet Nam, especially for motorbikes and passenger cars less than 10 seats. Therefore, the implementation of this system is still being postponed. Quang *et.al.* [10], in the research of assessing the EPR system for e-waste management has denoted the major culprits for this delaying as (1) the unclearness and imbalance of profit flows in EPR system, (2) the weakness of waste capacity and recycling abilities, and (3) the lack of supporting regulations. Since there is no any formal treatment/recycling line for ELV that has been reported in Viet Nam, most of ELV flows and material flows from ELV are under the control of informal sector, which is focused on recovery of the common material and usable parts of ELV for reuse. Because of that, ELV is considered a scrap source rather a specific waste that is needed to strictly control. As a result, it is the existed harmful risk for environment and public health caused by hazardous matters such as persistent organic pollutants (POPs) and PAH-related compounds, as well as other uncontrolled waste.

Up to present, there is no research on the situation of ELV management in Viet Nam except the publication of the joint research group at Ehime University (Japan) and VNU University of Science, Vietnam National University (Viet Nam) on the harmful effect of ELV processing in the craft village in Viet Nam [11, 12]. It is shown the fact that the ELV in Viet Nam is not attractive enough to scientists at the moment.

Since it is important to understand the flow of ELV, the material flows from ELVs in Viet Nam and the situation of ELV management system, which serve as a scientific and practical basis for the development and promulgation of a complete system of legal documents to strictly and effectively manage this waste. In addition, this is also the main basis to propose the best available technology (BAT) solutions for Viet Nam for safely dismantling, recycling and disposal of ELV to meet the legal requirements, as well as forming a secondary market for recovered material and usable part of automobile. The research is aimed to reveal the situation of ELV management in Viet Nam, as well as conduct assessment of the material flows of ELV, for the construction of compatible management system for this type of waste.

2. MATERIALS AND METHODS

For the estimation of the number of discarded ELV, especially in the case of passenger car (less than 10 seats), a simplified tool that is composed of the population balance model, logistic function and Weibull distribution is applied, based on the Vietnam household living standard survey data, which is taken every 2 years by General Statistical Office (GSO) [13]. The tool is first developed for estimation the discarded large home appliance in Viet Nam in our previous research [14] and applied in this research for estimation of ELVs. For the initial assessment of material contains of an ELV, a field trip survey was conducted in an automobile dismantling craft village in Vinh Phuc Province, Northern part of Viet Nam.

2.1. ELV inventory

The statistical data on average owner rate is used for the regression calculation by using logarithm function as in Formula 1.

$$n_t = \frac{n_{max}}{1+a.e^{-(b+ct)}} \quad (1)$$

where, n_t : the average number of car in household in the year t ; n_{max} : the saturated level of car in household; a is the number of times that the initial $n_f(0)$ must growth to reach n_{max} ; b is

considered the growth rate and c is the starting year of use. In this research, the year 1990 is chosen as the starting point for calculation

n_t is estimated by dividing the prediction population (is obtained from GSO [15]) to the prediction size of household in Viet Nam (is estimated based on the GSO data [13]).

The total number of cars (under 10 seat) by the Formula 2:

$$N_t = n_t * H_t \quad (2)$$

where H_t is the number of households nationwide at the end of year t .

The amount of discarded appliance in the year t (D_t) is calculated by population balance model as expressed in Formula 3 [15].

$$N_t - N_{t-1} = C_t - D_t \quad (3)$$

where N_t and N_{t-1} are the number in possession of car at the year $t-1$ and t . C_t is the total purchased car in the year t and D_t is the amount of discarded appliance in the year t . The owner rate of home appliances is validated and calibrated on comparing with the official data obtained from GSO [13].

The discarded rate for car in Viet Nam is determined by using Weibull function as seen in Formula 4:

$$\lambda(t) = \frac{\beta}{\eta} t^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^\beta} \quad (4)$$

where: $\lambda(t)$: annual discarded rate of car in the year t ; $\beta(>0)$: shape parameter; $\eta(>0)$: Weibull (scale) parameter, related with lifespan of car. In this research, β was selected at 20, which makes the lifespan of car ranged around 15-25 years.

The discarded volume in the year t can be done by the iteration calculation as in Formula 5:

$$D_t = \sum C_{t-i} \cdot \lambda(i) \quad (5)$$

where: D_t : the volume of discarded appliance in the year t ; C_{t-i} : the number of purchased cars in the year $t-i$ ($1 \leq i < t$).

A first-order sensitivity analysis has been conducted to find the most sensitive parameter among n_{max} , a , and b value, with N_t is the calibration parameter. The process starts with scanning runtime, which varied value of n_{max} from 0.02 to 0.1 and the interval is 0.01. Then, a minimizing the sum of squares of the residual approach was done to find the best-fit range (based on mean absolute error value-MAE and mean absolute percentage error value-MAPE) based on the owner rate of vehicle in household provided by GSO Viet Nam [13].

2.2. Field trip survey

A field trip survey was conducted in Te Lo industrial cluster, Te Lo Commune, Yen Lac District, Vinh Phuc Province. This place can be considered the biggest automobile dismantling center in the Northern part of Viet Nam, with about 1,000 households involved in automotive dismantling and businesses, nearly 400 dismantling businesses, 256 informal recyclers (mostly plastic, iron and iron products, aluminum), 280 informal mechanics processors (welding, soldering) in an area of 24 hectares.

Out of many types of automobile that are dismantled here, the dismantling of passenger car (less than 10 seats) is selected to survey. 12 questionnaire surveys were conducted in 12 dismantling businesses, to investigate:

- Type of business and the issued license for automobile dismantling,
- The support from local authorities for this operation,
- Type and weight of most valuable parts, including tires, mirrors, lead – acid battery packs, front and rear bumpers, lighters, front and back glasses, engines, clutches, gear boxes, fuel containers, air bags, catalyst converters, chassis and frame, doors;
- Source of automobile,
- Value of recover materials and parts (Vietnamese Dong-VND),
- Awareness of businessman and workers on environmental protection and related policy (especially the Decision 16/2015/QD-TTg.

The dismantling process was observed, and the dismantled parts were weighted. Since there are many types of discarded passenger car, the average weight of each part was used. Only major valuable parts (that can be recycled or reused) were investigated. There is also a difficulty in accessing information from the dismantling facilities in Te Lo, so the collected data are just for initial assessment. Besides, some of valuable parts were weighted for cross-checking with the questionnaire answers.

3. RESULTS AND DISCUSSION

3.1. ELV management in Viet Nam

3.1.1. Generation and collection

In Viet Nam, only the passenger car/bus (10 seats and above) and truck/van have regulated the lifespan. According to Decree No. 95/2009/ND-CP and Circular 21/2010/TT/BGTVT, the outdated vehicle is not allowed to transport, but there is not any regulation or guideline on dealing with it. There is also no guideline regulation for the manufacturers or importer to retrieve and treat the outdated vehicle, as well as the prohibition of purchasing outdated vehicle. The Circular No. 15/2014/TT-BCA dated April 04, 2014, of the Ministry of Public Security regulating the vehicle registration [16] only regulated the retrieval of license plate and vehicle registration of vehicle, but not regulated the responsibility of vehicle owner if not perform.

Yearly, the list of outdated vehicles is published by VRA, but only for the passenger car/bus (10 seats and above) and truck/van. The passenger car under 10 seats is not regulated so there is no any official information about this type of ELV. Because of that, the outdated car normally is sold to the private collectors, and thus, is put under the control of private sector that have full ability to collect, transport and dismantle them.

3.1.2. Treatment technology

Only manual dismantling process is applied to treat the ELV, and this process is done by the informal sector, with manual and outdated support tool. Since there is no any official formal enterprise registered for full treatment of ELV in Viet Nam at the moment, it is very important for the Government to create a legislation framework, open chance for the formal sector to take

control of this waste flow under a safe way for environment and public health, and also for the utilization of natural resources.

3.1.3. Regulation for ELV

In Viet Nam, ELV is first classified as hazardous waste under Decision 23/2006/QĐ-BTNMT dated December 26, 2006, of the Ministry of Natural Resources and Environment (MONRE) promulgating the list of hazardous waste [17]. Circular 12/2011/TT-BTNMT dated April 14, 2011, of MONRE on management of hazardous wastes [18], and the Circular 36/2015/TT-BTNMT dated June 30, 2015, of MONRE on management of hazardous wastes (which replaces the Circular 12/2011/TT-BTNMT) [19] continuously kept this type of waste in the regulated hazardous waste list. In these regulations, the ELV is classified into Category 15.01, including 15.01.01: ELV that contained hazardous parts, materials such as oil filter (Cat. 15.01.02), mercury containing (Cat. 15.01.03), PCB containing (Cat. 15.01.04), explosion part such as air bag (Cat. 15.01.05), asbestos containing brake (Cat. 15.01.06), lubricant oil and other oil (Cat. 15.01.07 and Cat.17), anti-setting agent containing (Cat. 15.01.08) and PCB or electronic element (Cat. 15.01.09) [18]. It means that when dismantling, there are lots of hazardous matters that are generated and needed to put under the Government control, according to the Circular 12/2006/TT-BTNMT [20] then, after, the Circular 12/2011/TT-BTNMT (and following, the Circular 36/2015/TT-BTNMT).

In 2013, ELV was classified as one of the five groups of equipment that are needed to retrieve and treat by the producer, under the Decision 50/2013/QĐ-TTg on prescribing recall and disposal of discarded products dated August 09, 2013 [21] (which is replaced by the Decision 16/2015/QĐ-TTg [7]). The Decision is considered as the first legislation document to deploy and operate the Extended Producer Responsibility (EPR) system in Viet Nam, which stipulates the responsibility on retrieval and treatment of the discarded product (including automobile) to the producer/importer/distributor. According to the Decision, ELV is considered specific waste that can be exempted of the registering of hazardous waste treatment when satisfy some defining conditions, such as to have license on product trade, to have equipment and solution to control the pollution and environmental protection, and to have equipment and specific equipment for the transportation of discarded products.

Nevertheless, up to present, the ELV, especially the discarded passenger car (less than 10 seats) generated from household, is never put under the control of Government. This waste flow is completely dominated by the informal sector including private collector, dismantler, and recycler. These activities, in addition to causing significant impacts on the environment and human health, also cause loss of natural resources through illegal dumping, destruction or even exporting of parts and materials that can be recycled/reused, but are beyond the capabilities of this informal private sector.

3.2. ELV inventory in Viet Nam

For calculation, an average life span of car is set to 30 years, that included the extended lifetime by refurbishing. Since the calculation results are not based on the survey data, it can eliminate some of impact factors that the other inventory cannot solve including the real lifespan of the automobile. Before, since the calculation is based on the lifespan, it is needed to conduct the field survey to obtain, but normally, only the possession time is provided by such a kind of survey. The saturated level n_{max} in household is considered the most important factor, which is

quite stable to determine the volume of discarded ELV, and the discarded volume of ELV depended on the owner rate in household and the lifespan.

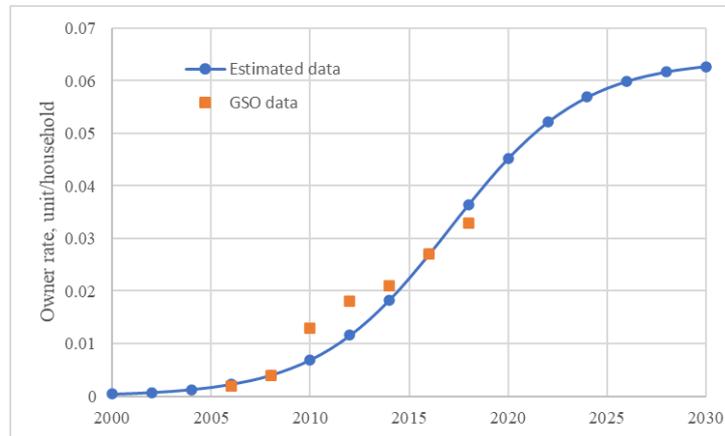


Figure 2. The estimate owner rate of car in household (unit/household).

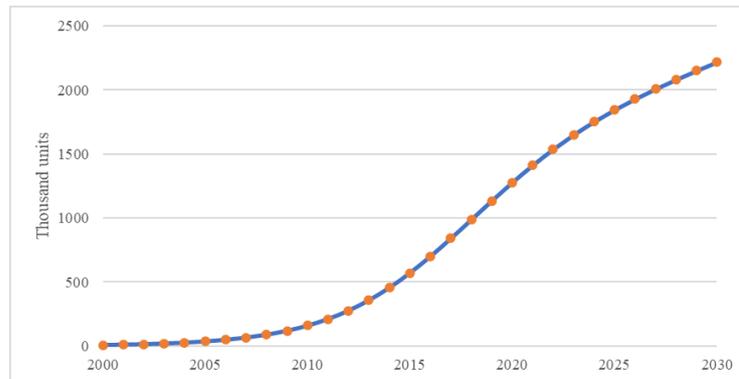


Figure 3. The estimate number of cars in household

The calculated owner rate of car in household is present in Figure 2. It is found that the owner rate of cars in household is quickly increased, and thus, increase the number of car and the shipment of the automobile market. By the 2030, the owner rate in household reach 0.062 unit per household, double it is in 2017 and 10 times higher in 2010. The trend of owner rate in Viet Nam is still in the marching phase before reach the balance. For the starting phase, the n_{max} is first selected from 0.02 to 0.1 unit/household and allow the estimation up to 2030. But for the saturated phase, it is needed to reset this value in accordance with the reduction slope based on the continuously data provided by GSO.

As seen in Figure 3, the number of cars in household are also increased in adequate with the increase of owner rate. In 2030, it is estimated at about 2.2 million passenger cars in household, where for the beginning of 2020, Viet Nam has totally 3.5 million registered automobiles (including passenger car). It soon leads to the increased number of discarded ELV as shown in Figure 4. Up to 2030, nearly 60,000 passenger cars will be discarded yearly, and as a result, nearly a hundred thousand tons of material are out of the state control if Viet Nam does not have any improvement in the waste management system.

For the calculation process, it is still exited of some gaps, such as the discarded rate due to Weibull distribution that did not have any actual data, the lack of calibration data in household

as well as the validation process. Nevertheless, it can be used for the short time prediction, and can show the trend of waste flow. The number shows that in the near future, if Viet Nam does not have proper management system, the informal sector can hold a very large flow of materials, and cause much more hazardous impact to environment as denoted by previous research [11, 12].

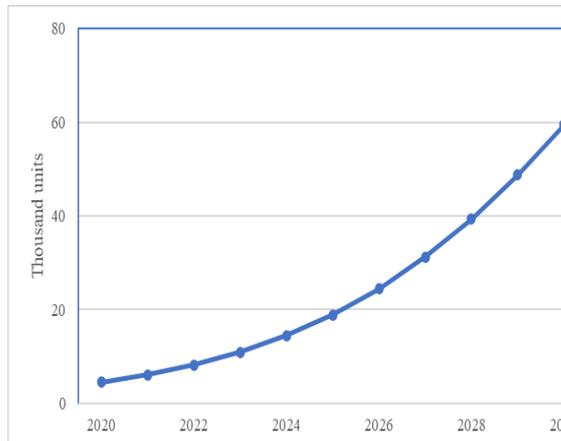


Figure 4. The estimate number of discarded cars in household (thousand).

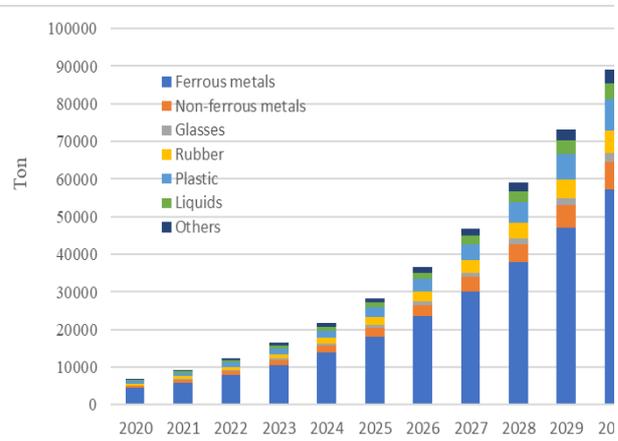


Figure 5. The estimate material flows of discarded car.

3.3. ELV flow in dismantling center

The survey in Te Lo commune, Yen Lac district, Vinh Phuc province, shows that daily, there are tens to hundreds of ELV and discarded construction machinery are dismantled here. The sources of ELV is included the private collectors, automobile services, liquidation from Department of Transportation and Department of Public Security. The dismantling process releases tons of uncontrolled waste such as grease, metal rust, rubber, sponge, rags, etc. It is not taken into account a certain amount of electrolyte solution from discarded batteries, dust and polluted emission from dismantling and mechanical processing. Meanwhile, there are numerous usable parts, that can be refurbished and brought back to the market for many purposes, such as replacing damaged parts, refurbishing used cars for multi-purposes. This situation will lead to many difficulties in the management, of ELV as prescribed before.

The weights of some valuable parts are shown in Table 1. The ELV flow in dismantling center is described as in Figure 5 and the material flow is summarized for a common ELV in Figures 6, 7, which is obtained from 12 questionnaires. There are three main outputs including usable parts (mirror, speaker, etc.) that can be reused or refurbished, dismantled common materials (metals, plastic, rubber, leather and glass) that can be recycled, and unusable materials that contained a lot of hazardous waste is discharged directly to environment. It is found that most of metal parts is recycled (80 %) or reused (20 %). The plastic is composed of PP, PE, PU and PVC with the rate of recycling is 46 % and disposing is 54 %. The glass is mostly reused (49 %) and disposed (51 %). It is found that more than a half of an ELV (57 %, in weight) can be reused, including mostly engine parts, wheels, air bag, speaker, chassis or mirror. About one third (32 %) can be recycled as secondary material resources, including mostly metal parts, some types of plastic and rubber. The rest (11 %) that cannot be reused or recycled is disposed without control at the dismantling site.

Table 1. Weight of some investigated parts in field survey in Te Lo.

Investigated parts	Number of weighting	Weight (kg)	Investigated parts	Number of weighting	Weight (kg)
Tires	5	22 - 24	Lubricant oil	3	6.2 - 10.5
Mirror	6	1.5 - 2	Front glasses	4	15 - 17
Door	4	20 - 25	Side glasses	5	6 - 8
Lighter	5	2 - 3	Bumper	4	16 - 18
Batteries	5	10 - 13	Volant	7	3 - 4

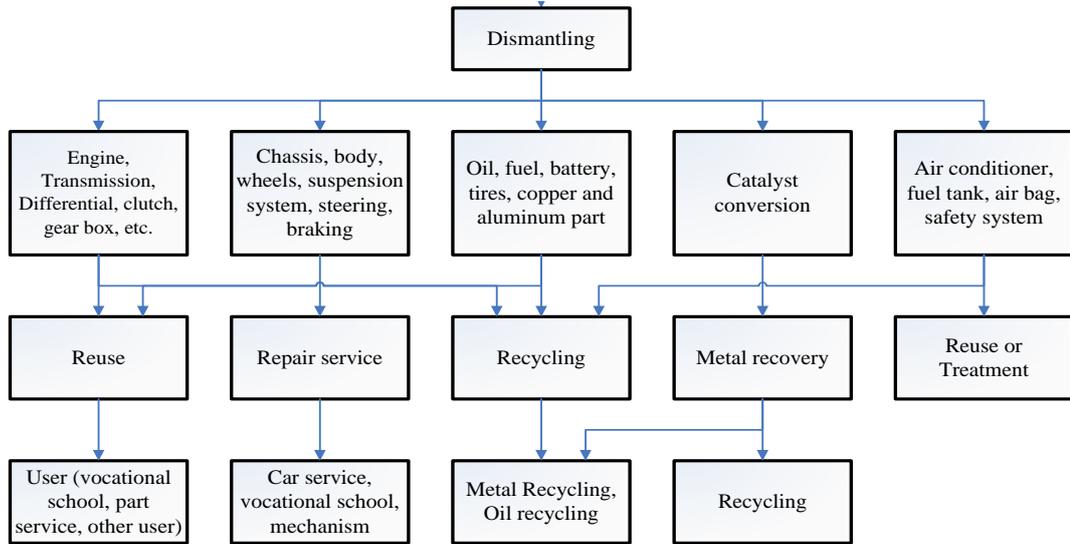


Figure 6. Common flow of ELV in the dismantling center.

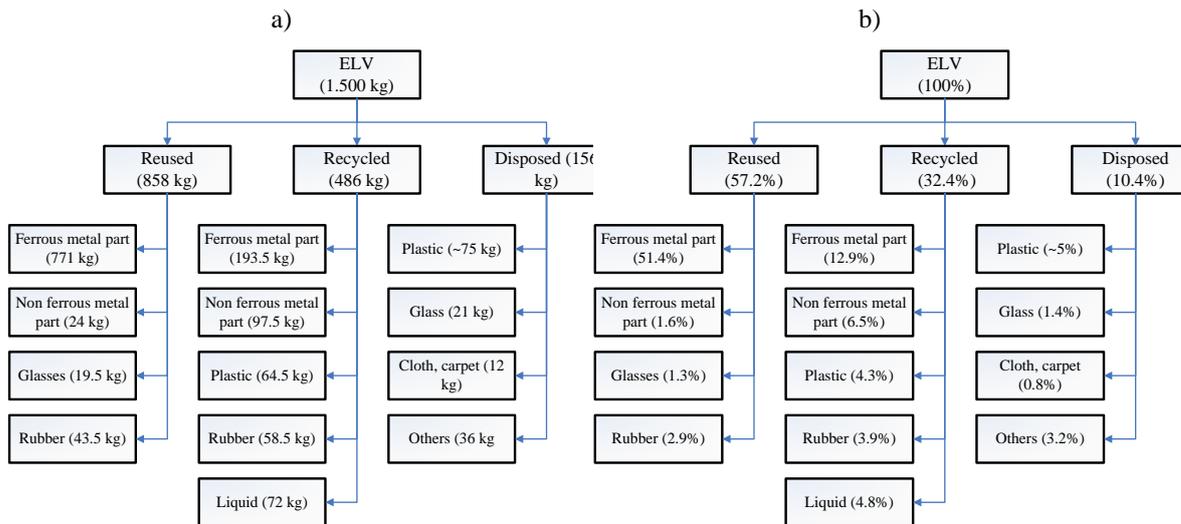


Figure 7. Material flow of an ELV (a) in weight, (b) in percentage.

Considering that the dismantling process in craft villages such as in Te Lo commune is common in Viet Nam, a large number of environmental issues has been founded by the research group of Ehime University [11, 12], especially problems regarding hazardous matters including heavy metals and POPs. With the increase of the number of ELV in the future, Viet Nam will have to face against the formation of a series of private dismantling sites if a proper infrastructure for the ELV management system is not prepared.

4. CONCLUSION

In this research, the increase flow of ELV in Viet Nam has been assessed. The calculation, although is conducted with some deficiencies that might affect to the inventory result. Nevertheless, the increased trend of ELV flow in Viet Nam can be seen, and the result can be proper scientific base for the forming of proper management system. The survey data on material flow shows that, it is still existed a decontrol and increased flow of waste and hazardous matter ran into environment and causes lots of adverse impacts to environment and public health.

The problem is that up to present, Viet Nam has not any preparation for receiving and managing this flow of waste, both in technical view and legislation view. Thus, it is still hanging for Vietnamese Government to improve the legislation and management infrastructure for the application of Extended Producer Responsibility system to manage this type of waste.

Acknowledgements. The research funding from Hanoi University of Science and Technology under research project code T2017-LN-02 was acknowledged.

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