An Inclusive and Effective End-of-Life Vehicle Recycling System in India: Balancing Economy and Ecology from Grave to Cradle

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ABSTRACT: *End-of-Life Vehicles (ELVs) in India are often recycled by car-breaking yards operating in the informal sector. In the absence of well-established, state-of-the-art ELV mechanisms, their work – ensures the crucial recycling of ELVs. Multiple qualitative analysis methods, such as desk study, literature review, and field visits, are utilized. Our study shows the following: car-breaking yards frequently work in an inefficient manner causing environmental hazards and health risks; the replacement policy adopted during vehicle servicing by Original Equipment Manufacturers and Authorized Dealers results in inefficient material use; Informal actors such as Private workshop owners and Reconditioning shops enable significant savings in material and costs, partly by substituting capital and energy with labor. We propose an inclusive 3R (reuse, recondition, and recycle) framework, which integrates various informal actors involved in ELV recycling. This sustainability-oriented framework ensures that the components and materials circulate in a closed loop.*

KEYWORDS: *Circular Economy; 3R - Reuse, Remanufacture, and Recycle; End-of-Life Vehicle; Inclusive supply chain; Sustainable development goals.*

INTRODUCTION

The extraction of raw materials such as fossil fuels, metal ores, and minerals requires enormous energy and water. Also, it generates a large amount of waste. We are losing freshwater ecosystems and marine water ecosystems at the rate of 6% and 4% a year, respectively [2]. A recent analysis by the World Wide Fund for Nature states that humans, with their current consumption pattern, are using 50% more resources than nature can replenish (Guardian, 2014). Since 1970 in 44 years, global emissions of CO_2 have increased by 90%.

In developing countries like India, more middle-class people possess higher purchasing power in the coming years. This will cause a drastic increase in resource consumption and industrial pollution (IGEP, 2013). Annual sales of passenger vehicles in India for the year 2017-18 were about 3.29 million units, and the number of registered cars by 2029 is estimated to be 100 million units (SIAM, 2019). This shows that the Indian vehicle industry is growing at a fast pace. In ten years, there has been a considerable increase in production plants. The absence of a proper end-of-life (ELV) recycling infrastructure to handle ELVs is a significant concern. The status quo of ELVs being processed by the informal sector in an unhealthy and inefficient manner pollutes the environment and generates more

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Fig. 1: End-of-Life Vehicles by the roadside.

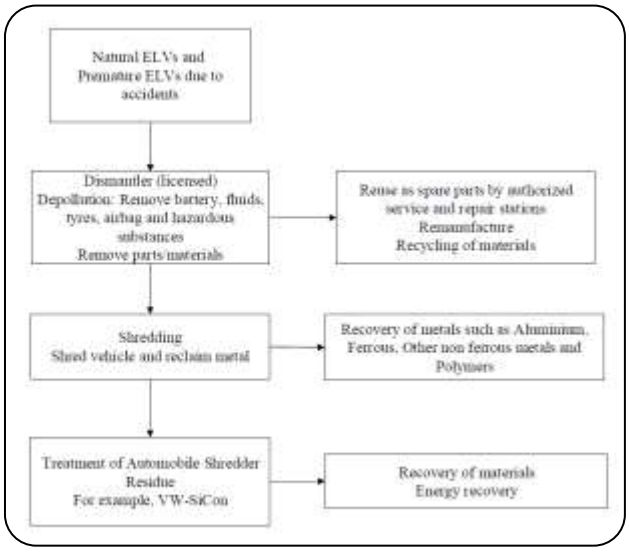

Fig. 2: ELV recycling process (own illustration based on Defra and BIS (2011).

wastes [Fig. 1]. Not many studies on ELV recycling in India have been carried out so far except [7]. There is a lack of information. A need exists to explore the topic and gather more information. Multiple sources of information such as scholarly articles, data obtained from interviewees, and observations including photos taken on-site, public-use files from GARC, sustainability reports published by OEMs, and annual reports published by car recyclers' newspaper articles are collected and used in this study.

A vehicle reaches its End-of-Life (EOL) under the following conditions:

1- When the maintenance cost of the vehicle increases due to the unavailability of spare parts

2- When it has been in use for more than 12 years

3- Due to performance degradation

4- When they are damaged during accidents and cannot be operated [11].

The car's entire lifecycle from the extraction of various raw materials to its disposal has been depicted [3]. The non-pollution procedure for the ELVs is described in Defra and BIS (2011). The ELV recycling process is presented in Fig. 2.

The biological systems recycle its resources efficiently on its own and continuously, in the same way, industries shall strive to close material cycles – by implementing material pooling at various levels, so the wastes from one industry become food to the other industry (also called as industrial symbiosis) [3, 15]. The traditional Industrial Economy optimizes production efficiency only up to the point of sale. Whereas the Loop Economy starts at the end of a goods utilization and brings goods and molecules back into a new use. Stahel (2010), founder and director of the Product-Life Institute, terms it a grave-to-cradle approach.

The transition from a linear (take-make-dispose) system to a circular (closing-the-loop) system is possible with the effective implementation of 3R (reuse, recondition, and recycle). 3R ensures a transition towards a low carbon economy, and functions using renewable energy such as manual labor. The 3R resource recovery process is cradle-to-cradle resource management [12].

- Reuse in two ways: Direct reuse, which includes second-hand trading, and repurposes, in which the same component is used for new purposes with or without minor modification [18].
- Remanufacturing /reconditioning - worn out/used components are given a new useful life. The term remanufacturing is used mainly when the product is upgraded and exceeds newly manufactured product standards [20]. Remanufacturing opens up new business opportunities, and it offers the same product many life cycles.
- Recycling completely transforms a product into molecules, whereas with repair, reuse or recondition, goods and components retain their shape [14].

30 years ago, environmental regulations focused on safe disposal, but today with the increase in pollution, waste generation, and raw material scarcity, regulations are framed focusing on Sustainability issues [12]. Examples of such directives are the ELV directive and Waste Electrical and Electronic Equipment Directive (WEEE).

ELV Directive has not yet been implemented in India. OEMs are not interested in establishing any recycling facility. Extensive research on ELV recycling practices in India has been conducted [7]. Their study's limitation

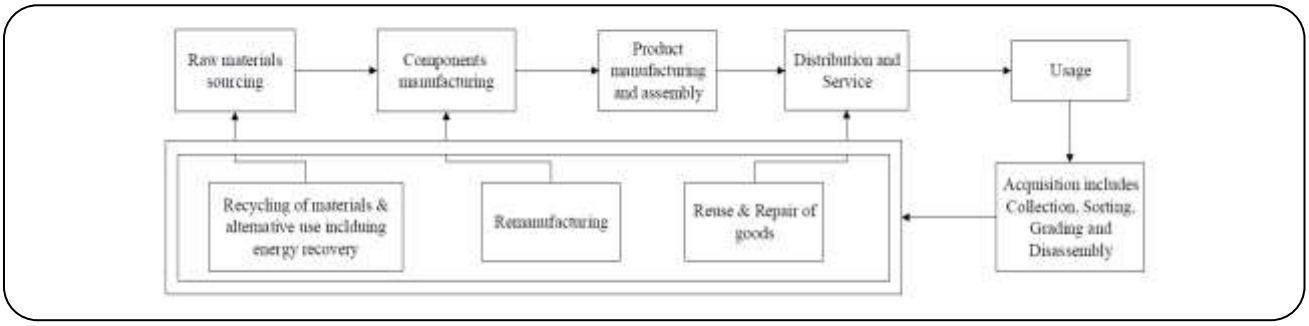

Fig. 3: Theoretical Closed-Loop Supply Chain

Is not taking the entire value chain into account and thereby missing out on some key actors. Efforts are taken toward the ELV recycling problem is mentioned in Automotive Industry Standards 129 [1].

- Society of Indian Automotive Manufacturers (SIAM), in association with the Automotive Research Association of India (ARAI), has outlined the roles of OEMs and Dismantlers in an effective ELV recycling
- At GARC (Global Automotive Research Center), a 28 steps ELV dismantling manual has been developed. What happens to the recovered spare parts of materials from ELVs is still a concern

Various recovery options for plastic parts obtained from ELVs have been mentioned in the study conducted. One of the important findings in their study is dismantling costs is one of the key factors in determining eco-efficiency performance. In developed countries like Germany, labor costs are high. The characteristics of ELV recycling in developed countries are mentioned:

- Heavy-duty machines with premium technology
- Requires huge capital investments
- A centralized ELV recycling process
- The result is faster processing of ELVs by intensive energy efficiency projects.

The dominant logic: By transferring the latest available technology from developed countries such as Germany to developing countries like India, the ELV recycling problem could be addressed. Maybe not because of the following reasons:

- Capital-intensive and automated technology is one of the key characteristics of the formal sector. Because of its capital-intensive nature, the formal sector's growth does not ensure more jobs [4]. There is a need for job creation in India, and such technology could only result in cutting down more jobs.
- The ELV directive likely demands the integration of the informal sector. Centralized ELV recycling is not much of a favor to the informal sector (CPCB, 2008). Research efforts are taken towards the ELV recycling demo unit focusing on manual dismantling.

The objective of this paper is to propose an inclusive ELV recycling system for India incorporating 3R practices. For that, it is important to research the following:

- Observation and analysis of current ELV recycling practices in India
- Examination of the role of various actors involved in the lifecycle of the car
- Examining the relationship between various actors to achieve an energy-efficient product recovery mechanism (closing the material loop)

METHODOLOGY

Entering the field with an initial framework serves as an anchor for the study and could be referred to while interpreting data [7]. The study's actors were chosen from the theoretical Closed-Loop Supply Chain (CLSC) model [Fig. 3]. With the help of theoretical CLSC, a conceptual 3R model is developed [Fig. 4]. The actors from the initial framework are discussed below:

- OEMs play an important role in initiating the ELV recycling industry, coordinating the various actors in the recycling network, designing environment-friendly products, and assisting dismantlers with dismantling manuals
- Remanufacture: Component manufacturers give new life to worn-out/used components.
- Reuse: Spare parts reused by dealers
- Recycle: Material recycling companies
- ELVs collection, dismantling, and redistribution by Dismantlers

Table 1: Formal and Informal actors interviewed.

S. No.	Actors	Number of samples	Type of interview
1	Private workshop owners (key informant)	2 (expert)	Observation, prolonged and multiple sittings
2	Authorized dealers	1 (competent)	Prolonged
3	Car breaking yards	1 (expert)	Observation and prolonged
4	GARC	1 (expert)	Observation, prolonged and archival data
5	Component suppliers	3 (1 expert and 2 competent)	Observation and prolonged
6	Reconditioning shops	5 (expert)	Observation and prolonged
7	Spare parts market	2 (1 expert and 1 competent)	Observation and prolonged
8	Used car market	1 (expert)	Prolonged
9	Insurance company	1 (expert)	Prolonged
10	Material processors/Recyclers	2 (1 expert and 1 competent)	Observation and prolonged
11	Original Equipment Manufacturers	1 (competent)	Prolonged

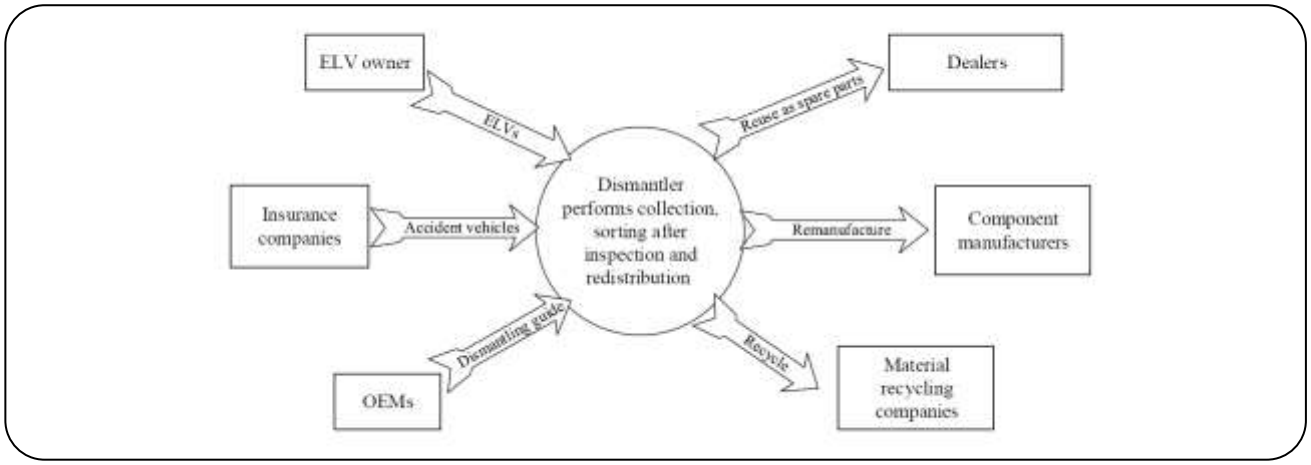

Fig. 4: Conceptual 3R model.

- Insurance companies in handling accident vehicles

After some interviews and data collection, there was an element of surprise. A considerable difference between the conceptual 3R model and the methods adopted in practice was observed. The actors' choice was revisited, and additional actors (mostly informal) were identified and interviewed.

- Private Workshop Owners (PWOs) have their garage to undertake car repair
- Spare parts dealer (parts reuse and resell)
- The reconditioning process used for parts reprocessing
- ELV recycling by car breaking yards

ELV recycling in India is carried out by informal actors, who hardly maintain any records [7]. Most informal actors such as PWOs, reconditioning shops, and car-breaking yards are incapable of speaking in English and lack computer skills. Hence it is not possible to research by using questionnaires. On-site interviews are conducted after observing the following actors' work: PWOs, spare parts dealers, reconditioning shops, and car-breaking yards. Observations proved useful because they stimulated the conversation and the emergence of new themes. Photographs taken during the study are used in this research paper wherever necessary.

The location is considered for research in Chennai, one of the eight metropolises with more than 5 million people. It has a high concentration of people doing business related to the automotive sector, and the goods movement is high. ELV recycling in India is performed by informal actors, who hardly maintain any records shown in Tables 1 and 2.

The interview guide helped carry out the conversation with the actors. Questions[13] were framed with the help

Table 2: Scrap value for the end of use materials and its destiny.

Product/ Material	Scrap (price in INR)	Current practices by car breaking yards	Source (Personal interview)
Motor oil	20/liter	Motor oil and fuel are collected for reuse and recycling	PWO
Tire	20/tire and 1 ton = 6000	Re-tread, burnt, or dump, depends upon the condition	Reconditioning shops
Bumper	20/kg	The bumper has a good potential for reuse and recycling because it is made of a mono-material	Insurance company
Battery	70/kg	Due to the high price of lead, they are regularly collected and recycled through the handling system is poor	Material processors
Mild steel and cast iron	24/kg	Good recycling rate	Car breaking yards
Copper coil	450/kg and 400/kg (burnt)	-	Material processors
Catalytic converter	-	Expensive materials ensure a high recycling rate	Spare parts market
Glass	-	If it is in good condition, stored for reuse or else dumped	Used car market
Light metals	-	Wheel made of aluminum has a good reuse and recycling rate	Used car market
Textiles and foam	-	Dumped because of its less scrap value	Material processors

Table 3. Questionnaires used for the actors.

1. What happens after you remove a part from a vehicle (Material Flow Analysis)?
2. How do you diagnose and evaluate a functional and non-functional part?
3. Please name parts on the classification of Remanufacture/Reuse/Recycle/Dump.
4. Quality of remanufacturing. a. Same as a new product b. Average c. Bad
5. Life of the remanufactured product. a. Good b. Average c. Bad
6. Cost advantages over a new product. a. Yes, b. No
7. Customer preferences. a. Mostly preferred b. less preference c. Not at all
8. Handling of used batteries (drainage of hazardous fluids). a. Yes, b. No
9. What is the market value of the electronic component, ceramics, glass, and tyres?
10. Neutralization of airbag systems? a. Yes, b. No
11. Motor oil, engine coolant, and windshield washer fluid. How do you store it? Does it have a secondary application? What is its value?
12. Chewing gum goods – once used and thrown away.
13. What happens to the below-mentioned components after their End of use/End of life? a. Air filter b. Oil Filter c. Rubber d. Brake Shoe, Clutch discs e. Electronic parts

of the EU ELV directive, the ELV recycling process in developed countries, the conceptual 3R model, and OEMs 3R best practices are shown in Table 3. Most of the questions are designed open-ended so that the interviewees could talk about their experiences as well. At times, the answers provided by one actor helped to frame questions for the others. The study evolved. PWO has been the key informant, who mentioned the reconditioning shops and explained some complicated business linkages in the existing ELV recycling chain.

FINDINGS

ELV recycling by car-breaking yards

Chennai is famously called 'The Detroit of India. More than 40 percent of India's car production and 35 percent

of India's auto component production comes from Chennai. Pudupet, an area in Chennai, is famous for dismantling ELVs and selling stolen vehicles. A police raid is normal in this area because of the occurrence of such illegal activities. On 19.08.2018, there was a police raid to clean up this 'roadside' car-breaking operation. ELV recycling did not take place on that particular day. With some help from corporation vehicles, all the piled-up dirt (a mixture of glass, rubber, plastics, and mud) left on the road was cleared. The next day, the car-breaking yard commenced as a regular activity.

Work process and its environment: The operations taking place in the South Coovam river were observed for a week. They were breaking a Tata Indica car registered in the year 2006, which has reached its EOL. ELVs were being recycled on the roads by car-breaking yards as if it is some 'roadside business.' The shop owner has employed 2 people. "In a single day, they break at least 3 vehicles. Our observations include:

1- The employees are not provided with adequate tools. The most used tools are hammer and spanner [Fig. 5]. Using the right tools for dismantling not only makes the job easier but also results in the efficient recovery of components and materials

2- Hazardous work environment: There is no provision to collect and store materials such as oil and glass, which causes physical damage to the workers

3- The wastes are not segregated at the source, which diminishes the recovery potential of the value residing in the materials.

The dismantling process starts with the body of the car. It is one of the most reused components. In good condition, it is sold directly to the re-sellers. Or else, the body of the car is cut into small chunks using gas [Fig. 6]. The body's metal pieces are stored in the warehouse until it reaches 1000 kilograms, and then it is sold to the material recycling companies. The problem with the cutting process is the enormous release of toxic gases resulting in air pollution. It also causes an unbearable situation for commuters, people living in the area, and mainly the workers themselves.

Removal of spare parts takes place once the car body is taken off. Mechanical parts such as Engines, Crankshaft, Camshaft, etc., are sold to reconditioning shops or aftermarket shops, or recycling companies depending upon the condition. Electronic parts such as the electronic control unit, plastic parts such as the bumper, and car seats are either stored or disposed of depending upon their condition [Fig. 7]. The remains are the materials such as floor

Fig. 5: Usage of inefficient tools - Breaking the car body with a hammer.

Fig. 6: Gas cutting of ELV body parts.

Fig. 7: Aftermarket shop.

mat, the cloth used in the interiors, glass particles, wires, plastic tubes, seat form, and electronic boards disposed of in the street [Fig. 8]. Brake fluid, windshield coolant, and acid from the batteries are drained away in the streets.

This results in land pollution (waste generation and soil degradation), the substances mentioned above are prohibited from dumping under the rules 'The Hazardous Wastes (Management and Handling) Rules, 2003' and 'The Ozone Depleting Substances (Regulation and Control) Rules, 2000'). As shown in [Fig. 9], there are some tires, glass,

floor mats, and foam floating in the river causing huge water contamination and blockage.

Formal vs. informal actors in the maintenance stage of the vehicle

The owners of vehicles such as Tata Ace are largely from the poor and lower-middle economy. If there is any problem (for example, component damage or component wear) during the vehicle-in-use stage, the Replacement policy (replacing a new component with the defective one) adopted by Dealers is not an affordable solution. In such a case, component life extension as an alternative solution is provided by the local reconditioning shops and PWOs.

An expensive solution resulting in more waste: The damaged parts removed during vehicle servicing are replaced with new parts at the authorized dealer station. Primarily, instructed by OEMs to follow replacement policy and certain sales targets for spare parts to be achieved every month. The dealer replaces the damaged part with the new one, and insurance is claimed for it. The part is disposed of, the third party performs some rework and enters the grey market.

Effective utilization of materials: According to remanufacturers fall under any one of these categories: Original equipment remanufacturers, contract remanufacturers, and independent remanufacturers (IRs) [16]. Currently, most of the reconditioning activities in India are performed by reconditioning shops or IRs. The characteristics of these shops are small-scale, labor-intensive, local, and independent [10]. The first step in reconditioning is inspecting the product. Normally, PWOs recognize the problem in the component and direct it to recondition shops. The most commonly performed machining operations are turning in Lathe, drilling holes in Milling, Grinding, and honing parts to ensure good finished surfaces. The operations performed in reconditioning a component are as follows: First, the product is completely disassembled. Second, the parts are thoroughly cleaned, and the worn-out parts are replaced with new parts. Third, machining operations are performed on individual components [Fig. 10 is reconditioned Engine]. Fourth, the parts are inspected for tolerances, and the product is reassembled. 2-3 persons have to work for 2 days to recondition an Engine. PWOs and Reconditioning shops are doing a far better job than formal actors (OEMs and Dealers) in the vehicles' maintenance stage. They truly represent the caring economy by saving materials (recovering the raw material's value and extending the life of the components and product) and offering service at an affordable cost.

Fig. 8: Material dumping resulting in land pollution.

Fig. 9: Illegal dumping of materials in the river.

Fig. 10: Reconditioned Engine.

RESEARCH IMPLICATION

"The key to most successes in waste reduction and energy conservation is not break-through science or high

Table 4. Application of de Brito and Dekker's reverse logistics network design framework.

de Brito and Dekker's framework	Application of the framework
What are the products entering and leaving the reverse logistics network?	The products entering the network are the ELVs from individual users and accident vehicles from Insurance companies. After collection, sorting, and inspection, the materials, and components (spare parts) are sent to the respective actors for product/material recovery
How will the components be recovered?	Depending upon the condition of the component, which is redistributed for reuse or reconditioned or recycled
Whom are the actors involved in the reverse logistics network and their functions?	Source: Insurance companies and individual users Collector (includes sorting and redistribution): Authorized dismantling plant Processor: Reconditioning shops and Material recycling companies Customer: PWOs, spare parts market, and used car dealers Initiator: OEMs
Why should reverse logistics activities be initiated (driving forces)?	Corporate social responsibility improved green image and proactive approach to ELV directive

technology, but institutional innovations in management [17]."

Closing the material loop

An empirical model (see Fig. 11) is constructed using de Brito and Dekker's reverse logistics network design framework (refer to Table 4) and the inputs obtained from the observation [8]. The purpose of the framework is to coordinate and integrate various actors such as OEMs, insurance companies, individual users, reconditioning shops, PWOs, used car dealers, aftermarket shops, dismantlers, and recyclers to ensure shared responsibility in reducing the environmental impact of the product throughout its life cycle.

Sourcing Accident vehicles from Insurance companies: In the United Kingdom, 10-15% of ELVs have heavily damaged accident vehicles. Nearly 200 to 300 four-wheelers get de-registered every year due to accidents in a single branch. The accident vehicle is considered a total loss when the repair cost is 75% of the Insured declared value. The scrap vehicle's price is fixed by a Market surveyor from Insurance regulatory development authority and auctions it to the car breaking yards.

Reuse - An additional source of spare parts: Strongly objects to the statement that retired products are meant only for recovering metal. The average life of a car is around 10 – 15 years. After a certain period, OEMs stop producing spare parts [9]. In that case, spare parts recovered from ELVs by dismantlers are more valuable.

- Parts obtained from authorized dismantling plants are of great help to PWOs. They work in close relationships with customers and reconditioning shops. First, they ask the customer's opinion about whether to replace or recondition the component. Most customers prefer to recondition because of the low-cost factor. By obtaining cost-effective and easily available used parts from Dismantlers, PWOs will benefit from keeping the costs low for their customers and reducing the cycle time. For the same reason, used car dealers are also much in favor of buying parts from dismantling plants.
- Aftermarket shops could store these components and resell them to other customers. Reconditioning shops and aftermarket work in tandem. Their effective cooperation results in the 'availability of spare parts for a long time and 'the market's existence for second-hand components.' A report from OECD on product durability and product life extension concludes that these two are crucial factors for product life extension.

Reconditioning is a sustainable solution centered on the reuse of components and the recycling of materials. More than 20 car components, such as starters, alternators, clutches, and electronic control units, are often remanufactured [3]. The aftermarket in India is poorly organized, and most spare parts are counterfeit. An authorized dismantling plant establishing a partnership with reconditioning shops (equipped with non-destructive testing for quality assurance) and offering spare parts with a warranty could bring down counterfeit spare parts to a certain level. Moreover, the experience of the reconditioning shops could improve the effectiveness of the dismantling plant.

Material recycling: Ferrous and non-ferrous metal contributes to 76% of the car's weight, and the remaining 24% comprises plastics and polymers, tires, glass,

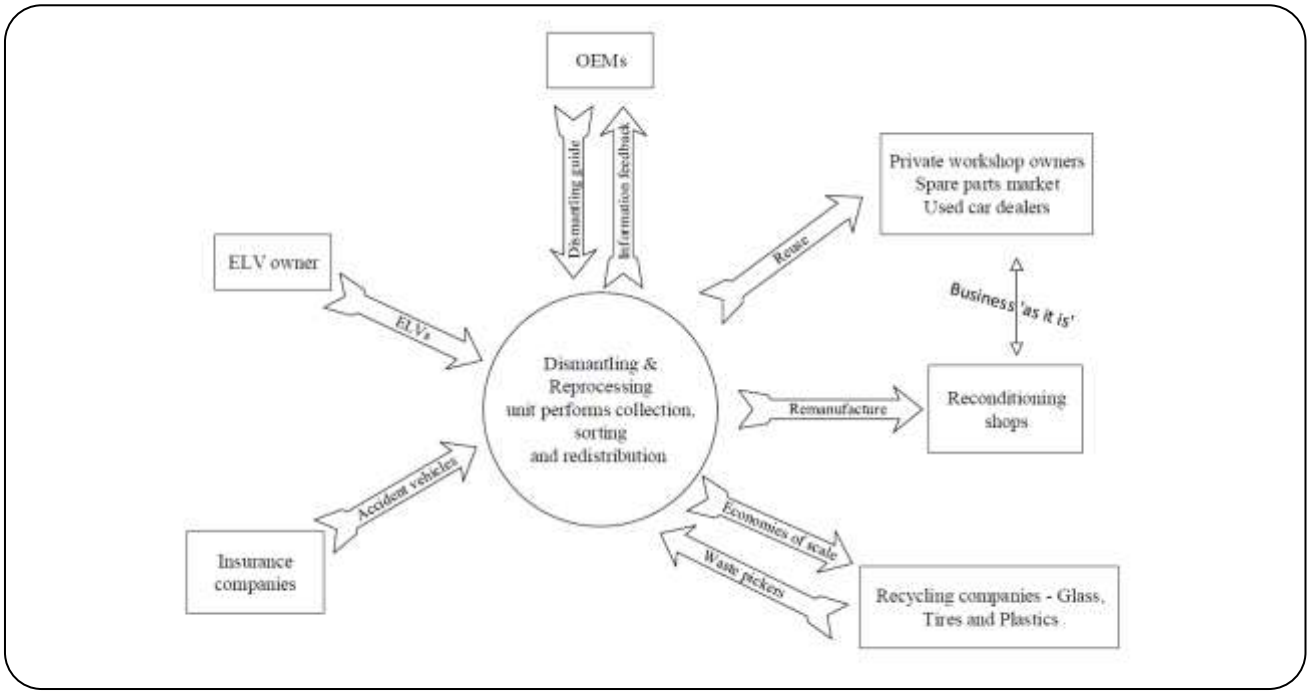

Fig. 11: An Inclusive and Effective 3R ELV recycling system (own illustration).

batteries, fluids, textiles, and rubber. Because of its better material recycling rate, ferrous and non-ferrous metals are quickly sold in the secondary market. The problem lies with the remaining 24% of the car's weight. Though materials such as tires and plastic contribute to comparatively less weight, it has a severe effect on the environment when they are not effectively introduced back into the material loop. Such materials need to implement 'Industrial symbiosis' (between firms), where waste from one industry becomes food for the other industry. Currently, broken *glass* from the car is dumped. But it could be resold as scrap material to the glass production industry, or it could be used in the construction of roads. Due to the lack of space and their careless waste management, car-breaking yards dump or burn materials such as *tires*. In the US, recycled tires are used to produce new products such as brake pedals and floor mats, and worn-out tires are used in the cement industry as supplementary fuel [2]. Car-breaking yards dump some of the *plastics* recovered from ELVs. Extensive research on different recovery routes such as mechanical recycling, feedstock recycling, and energy recovery for different plastic parts such as a bumper, air intake manifold, etc., has been studied. One of the study's important findings is to employ open-loop recycling for plastics rather than closed-loop recycling.

Integration of waste pickers: Employing informal waste pickers for the collection of materials such as plastic, glass, and the tire should be a win-win for the Economy and Ecology. It also ensures economies of scale at a lower cost. A study described the integration of the informal sector into solid waste management in developing countries and concluded that such integration could ensure more social and economic benefits, and it is necessary. If waste pickers are made responsible for collecting low-value materials and integrating them into closed-loop ELV recycling, it could turn unemployed poor people into entrepreneurs.

OEMs proactive approach to legislation: For an efficient end-of-life product recovery, transparency in the supply chain is essential. Agfa-Gevaert was the first company to develop recycling passports for electronic equipment. It consists of a dismantling guide and information about the product's materials to facilitate easy recycling [19]. Automotive Industry soon followed it. In consortium with other OEMs, Volkswagen developed the International Dismantling Information System (IDIS) in the year 2010. IDIS provides necessary instruction on removing fluids such as brake oil and coolant oil, and easy removal of components, including airbags and tools required to carry out ELV dismantling safely and easily [2]. Another useful

The information system related to ELV recycling is International material data systems (IMDS), which is in effect since 2008. The main purpose of IMDS is to collect, maintain, analyze, and store the materials database used in automobile production [3]. The existing car-breaking yards do not have the necessary infrastructure to use information systems such as IMIS and IDIS for effective dismantling and an online platform to sell materials in the secondary market. *Information systems and physical infrastructure* are the key factors that third-party service providers such as a dismantler should possess for a successful reverse logistics operation [12]. OEMs could achieve a competitive advantage in the market by taking a proactive approach to establishing a recycling infrastructure and supporting an authorized dismantling plant.

Policy measures for ELV directive and aftermarket service policy

Government policies in India are framed so that it provides social benefits for poor people. E-waste (Management and Handling) Rules, 2011 is one example. The National Environment policy encourages informal actors (waste pickers) in the collection process of waste. An E-waste agency on a state level has been established to coordinate formal and informal actors and government bodies for efficient e-waste recycling. As a result, informal e-waste recyclers such as E-WaRRD partner with formal e-waste recyclers.

- Identifying the appropriate informal actors (for example, PWOs and Reconditioning shops) and clarifying their roles for effective integration, implementing skills enhancement programs, ensuring shared incentives and social protection
- Parts such as oil filters and fuel filters are changed every 10,000 kilometers by Authorized dealers during car service. The safe disposal of such hazardous materials is not in place. OEMs should buy back such hazardous substances and ensure proper disposal of the same
- The automotive aftermarket in India is still an unorganized sector. A major challenge faced by both Authorized dealers and aftermarket shops is the surge in the import of cheap and low-quality spare parts from China. Chinese automotive products are so cheap that consumers prefer buying a new one to repairing the damaged part. Recognizing and implementing an aftermarket service policy could improve growth prospects [5]. The government offering legislative support to the reconditioning shops and providing incentives to equip themselves with adequate technology will benefit the Indian Automotive Aftermarket.

CONCLUSIONS

ELV recycling practices in India are far from Sustainability. The employee's environmental degradation and working condition are not much of an importance for the car breaking yards. Their motive is to make money, 2 persons on a single day break 3 vehicles. Indian Automotive Industry needs a proper recycling system, which could do more with less (resource productivity) and brings a necessary shift from 'more input equals more output' to 'keep going but use less and waste less'.

By establishing an inclusive and effective 3R ELV recycling system, materials are taken from the grave (ELVs) and effectively put back in the cradle. This would result in job creation and resource productivity – a balance in Economy and Ecology.

- The parts obtained from ELVs could be effectively used by various actors involved and thereby closing the material loop. This results in a considerable increase in resource efficiency and reduction in resource depletion – addressing Sustainable development goals (SDGs) such as industry, innovation and infrastructure, Responsible production and consumption, and Climate Action
- Efficient hazardous waste management and reduced waste generation; land, water, and air pollution could be mitigated - addressing SDGs such as life below water and Life on Land.
- By integrating appropriate informal actors, more social and cleaner 'green-collar jobs could be created for the people at BoP, ensuring *poverty mitigation* to a certain level – addressing decent work and economic growth. The proposed ELV recycling system is good for the consumer, business, and the environment and ensures Sustainable development.

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