Framework for Building a Circular Economy for End-of-Life Vehicles in India

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Introduction

The increased consciousness of our surrounding environment and concerns linked to degradation of the same has led to many regulations around manufacturing and disposal of products of various kinds. Vehicles are one of the critical products that characterize consumer lifestyles, particularly that of the middle class segment of population in developing countries such as India. Over the last decade, India has been experiencing one of the highest motorization growth rates in the world. By 2015, there were over 200 million motorized vehicles registered (SIAM, 2015). A vehicle's average life is considered to be between 10 to 15 years, after which it is expected to enter the retired/end-of-life (ELV) phase. Estimates for India suggest that more than 8.7 million vehicles have reached the end-of-life phase by 2015, and this number is expected to rise to 21 million in 2025 (Akolkar *et al.* 2015)[4]. In addition to this, the recent ban of National Green Tribunal (NGT) on 10 year old diesel vehicles and 15-year old petrol cars in Delhi and surrounding areas implies that more vehicles will no longer be considered fit for transportation and will need to end up as ELVs.

During a life cycle assessment to gauge the environmental impact of a vehicle is done, there is attribution of impact to all stages of the life cycle. There is impact at the stage of extraction of the raw material, in the use of energy during the assembly phase, in the transportation of the manufactured vehicles to the customers, during the use phase of the vehicle, and finally at the disposal stage (ELV management)[5]. ELVs can also be an important source of secondary raw materials, such as metal and other materials, which if salvaged and/or reused/recycled, can be again fed into the economy thereby helping to close the loop of sustainable resource circulation and reducing the demand for virgin raw materials. Estimates suggest that steel scrap worth INR 115 billion can be generated in India from retired vehicles.[6]

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). These countries have recognized that a distinct ELV law is necessary within the framework of the extended producer responsibility (EPR) framework and have reported success in controlling the number of ELV off the road. Also the evolving global environmental awareness, shrinkage in availability of landfill area, and depletion of natural resources are among the factors which have driven a number of developing countries in adapting strategies towards product recovery.

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[4] Akolkar, AB; Mita Sharma, Meetu Puri, Bharati Chaturvedi, Gautam Mehra, Supriya Bhardwaj, Dieter Mutz, Rachna Arora and Manjeet Singh Saluja 2015: The Story of Dying Car in India. Part II. Report prepared on behalf of GIZ, CPCB and Chintan. New Delhi: CPCB.
[5] Estimates point out that if older trucks and buses are scrapped it would result in a 17 % reduction in CO2 emissions, 18 % reduction in Hydrocarbon and Nitrogen Oxides emissions, and 24% reduction in PM emissions. (Ministry of Road Transport and Highways, Government of India)
[6] http://economictimes.indiatimes.com/news/economy/policy/vehicle-policy-to-generate-steel-scrap-worth-rs-11000-crore-per-annum/articleshow/52598995.cms

Currently ELVs in India usually end-up in the informal sector, such as the scrap yards at Mayapuri, New Delhi, or Pudhupet, Chennai. In these scrap yards, there is dismantling (stripping vehicles and scrap metals and recovering all sorts of parts) that happens using crude ways, after which the recovered auto components are either refurbished and sold in the second-hand market (directly to end use consumers or traders of second-hand parts) or the material resource is recovered from these components and sent for recycling (in many cases for down cycling). Although certain regulations have been introduced for better ELV management, yet lack of standard operating procedures, ambiguity in deregistration of vehicles, poorly informed consumer practices, prevent effective management. This calls for revisiting and understanding existing practices and the policies, and exploring opportunities that not only makes economic sense, but can create social values and prevent environmental degradation. These countries present learning in terms of what is required for a successful implementation of an ELV law.

In this paper, the authors attempt to use the circular economy framework to explore and develop a business model for improving sustainability of ELV management in India. To do this, a SWOT (Strengths, Weaknesses, Opportunities and Threat) analysis is done for current ELV management in India and then this analysis helps to identify ways to build up on the strengths, address the weaknesses and threats and tap the opportunities for supporting a circular economy in the ELV management in India. For this, learning from across the world is also drawn. A structure of stakeholder engagement required for generating economic profitability and social benefits to the different stakeholders in addition to the preservation of the environment, is also suggested in this paper.

Need for a Circular economy framework

One of the major issues that the world is currently grappling with is the unprecedented growth in demand for various resources and the associated challenge in meeting this demand. The outcome has largely been driven by the rapid industrialization of emerging economies, as well as the continued high levels of material consumption in developed countries, although some evidence of absolute decoupling in certain developed regions of the world have been observed in recent times, led by the European Union (EU). Never in the past has the conflict between economic growth and resource consumption found such high attention by different stakeholders as has been observed in the recent times.

Developing countries too are experiencing the pressure on demand for resources and this is only likely to increase in the future due to many factors including growing population, rising aspirations of the vast middle class, demand for improved lifestyles and increased urbanization. According to UNEP-Data, India consumed about five billion tons of materials in 2010, out of which about 42% were renewable biomass and 38% non-metal minerals, fossil fuels and metals. Projections indicate that by 2050, the total consumption of biotic and abiotic materials will be nearly fivefold compared to 2010 and the share of abiotic materials will be four times that of biotic materials. (UNEP, 2016)

The current linear economy approach results does not allow us to close the loop from production to consumption to secondary resource management and channeling back of these resources back into the economy. The massive waste generation at all stages of a product life cycle right from resource extraction, processing, value addition, consumption and end of life stage needs to be looked at and ways identified to minimize this waste generation and enhance recovery and reuse of resources. Products could be developed which are easier to repair and not difficult to recycle. Implementing a Circular Economy approach would thus be one effective method to ensure this and enable output (including waste generated) of one business/entity/individual to become an input for the other and thus encouraging recovery from waste . While substituting secondary materials for primary materials can offer a part solution, the circular economy goes beyond recycling as it is based around a restorative industrial system geared towards preventing waste and reusing materials, thereby promoting sustainability and resource management. In addition to the environmental

pressures brought by the traditional linear economy, the main economic reasons to mainstream the concept of the circular economy have been high and volatile commodity prices and potential multi-billion economic benefits from new market opportunities. However it is to be noted that *'one-size-fits-all'* approach cannot be followed when it comes to adopting the circular economy package prescribed by the developed world. In order to effectively close the loop, we need to contextualize the circular economy framework for India and integrate the informal sector (where much of the end of life products gets treated) into the framework.

To be able to accelerate the transition towards circular economy, technological intervention will be needed to help recover resource from waste and also enable its reuse in manufacturing of goods and services. Further, consideration of product as a service needs to be promoted and there should be creation of leasing options and sharing platforms where product remains owned by company and consumer pay for its usage. The idea seems to have found seeds in the recent start -ups of Zoom car, Ola Uber etc. Convenient pay-per-use models that give people access to tailored transportation, whenever required, can replace the need for vehicle ownership (Ellen McArthur, 2016).

What will also be essential is that circular economy standards be incorporated into procurement law or guidelines, lists of preferred suppliers or materials can be drawn up, and skill in total cost of ownership (TCO) and measures of material circularity can be built in procuring departments. Gaps in public infrastructure for waste collection systems and treatment facilities will need to be addressed as this will enable private sector circular economy activity (Ellen McArthur, 2015[7]).

Circular economy and Mobility

In the context of addressing the broader sustainability related challenges, mobility has a very important role to play, and India is no exception in this context. But enabling mobility through different transportation options and related infrastructure is associated with negative impacts – high resource and energy intensity, and is often one of the highest contributors to pollution, including GHG emissions. In 2010, less than a quarter of motorized trips were completed in personal vehicles (2 and 4 wheelers); however car ownership is increasing rapidly on account of rising income. Automobile manufacturing requires different metals-steel, aluminium, copper, lead, chromium, nickel and zinc, as well as significant amounts of plastic, glass, rubber and fabric. Analyzing the direct and indirect raw material requirements in the Indian automotive sector during the period 1997-2007[8], it was found that the material requirement of the sector doubled in a period of 10 years. If current growth trends continue, the total number of registered cars could exceed 100 million by 2030, with a concomitant rise in material requirements. Under business as usual scenario, the total material demand from 2015 to 2030 in the auto sector is expected to increase from 14.1 million tonnes to 102.1 million tonnes (TERI- GIZ-DA, 2016). Thus, identifying the ways to manufacture efficiently and promote the substitution of virgin raw materials with secondary raw material where possible (after taking into account relevant safety issues if any), minimize waste generation in the production process and encourage recovery of resources from the waste generated will have far reaching benefits in terms of resource security and environmental sustainability. Thus, the fact that resources are finite not only calls for using the virgin resources diligently, but creates a surmounting need for secondary resource management for decoupling economic growth from resource use.

With demand for personal mobility in India expected to double or even triple by 2030 (IGEP, 2013), integrating circular economy principles into the existing mobility system would help addressing some of the growing needs of the Indian population, especially in cities, while limiting negative externalities, such as GHG emissions, congestion, and pollution. A multimodal, door-to-door, on-demand mobility system, embracing vehicle-sharing trends and leveraging digital innovation, could provide efficient and effective transportation with high vehicle usage and occupancy rates. Ellen

[7] https://www.ellenmacarthurfoundation.org/publications/delivering-the-circular-economy-a-toolkit-for-policymakers
[8] Material Consumption patterns in India: A Baseline study of the Automotive and Construction Sectors, March 2016

McArthur (2016) estimates that a circular economy development path for mobility and vehicle manufacturing could create annual benefits of 31 lakh crore (US$ 482 billion) in 2050, compared with the current development scenario. Following the circular path would also reduce negative environmental impact, with 68% less GHG emissions from transportation and vehicle manufacturing and 82% less consumption of virgin materials.

In a recent project titled '*Resource Efficiency and Sustainable Management of Secondary Raw Materials'* supported by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), the authors engaged in an exercise to understand the ELV management system being followed in Delhi and also estimated the different types of raw material that is present in the category of vehicles-taxis which are expected to reach end of life in Delhi-NCR. These estimates were calculated by the authors based on the weighing of scrap generation from actual dismantling of few of these vehicles (Refer Table 1).[9]

Table 1: Material available for secondary use: A case study from taxis in Delhi-NCR

	No. of Taxis*	Average weight of a Taxi (in Kilograms)	Total weight of Taxis (in Kilograms)	Plastic (in Kilo-grams)	Steel (MS+HSS) (in Kilo-grams)	Rubber (in Kilo-grams)	Foam (in Kilo-grams)	Aluminium (in Kilo-grams)	Copper (in Kilo-grams)	Glass (in Kilo-grams)	Other (in Kilo-grams)	Synthetic (in Kilo-grams)	Poly-carbonate (in Kilo-grams)
Delhi	75629	1000	75629000	3810464	51909545	3018285	639409	11736246	474400	1542144	82504	521153	137507
Gurgaon	4869	1000	4869000	245318	3341940	194317	41165	755580	30542	99283	5312	33552	8853
Sonipat	1065	1000	1065000	53659	730985	42503	9004	165269	6680	21716	1162	7339	1936
Faridabad	9181	1000	9181000	462572	6301571	366405	77621	1424724	57590	187209	10016	63265	16693
Noida+ Gaziabad	17500	1000	17500000	881714	12011491	698409	147955	2715682	109773	356841	19091	120591	31818
Total				**5453726**	**74295533**	**4319920**	**915154**	**16797501**	**678985**	**2207194**	**118084**	**745900**	**196807**

These estimates would also indicate the maximum amount of raw material available for secondary use from this source and a potential reduction in demand for virgin raw materials if the secondary raw material is reused. Designing vehicles for reuse, components for remanufacture, and materials for recycling can close loops and reduce upstream demand for materials and energy. Coupling this with circular business models that focus on product as a service maximize value capture for businesses. Collaboration with the informal sector can create the necessary reverse logistics networks.

Remanufactured parts can be 30-50% less expensive while having the same guarantee and quality control as new parts. Remanufacturing a passenger car engine uses only 23% of the energy used to produce a new engine from raw materials (Ellen McArthur, 2016). Businesses that identify ways to close material loops can realize greater profit margins through alternative revenue streams and lower manufacturing costs. Indian companies are starting to recognize these benefits.

Tata Motors Prolife, for example, has realized the value of remanufacturing components in their commercial vehicles as these vehicles have long use cycles, are very sensitive to cost increases, and are often managed as a fleet, making the use of remanufactured parts more attractive, especially with a warranty. Tata Motors Prolife buy-back, or exchange, the used vehicle parts like engine, gearbox, or alternators. The company then remanufactures the returned part and offers the remanufactured product with a warranty. This approach allows longer use of parts, reduces demand for energy and materials, thereby creating new revenue streams for Tata Motors Prolife.

[9] Authors would like to acknowledge the support provided by Cartiff and the informal sector dismantlers of Mayapuri area in helping estimate the raw material content in the ELVs.

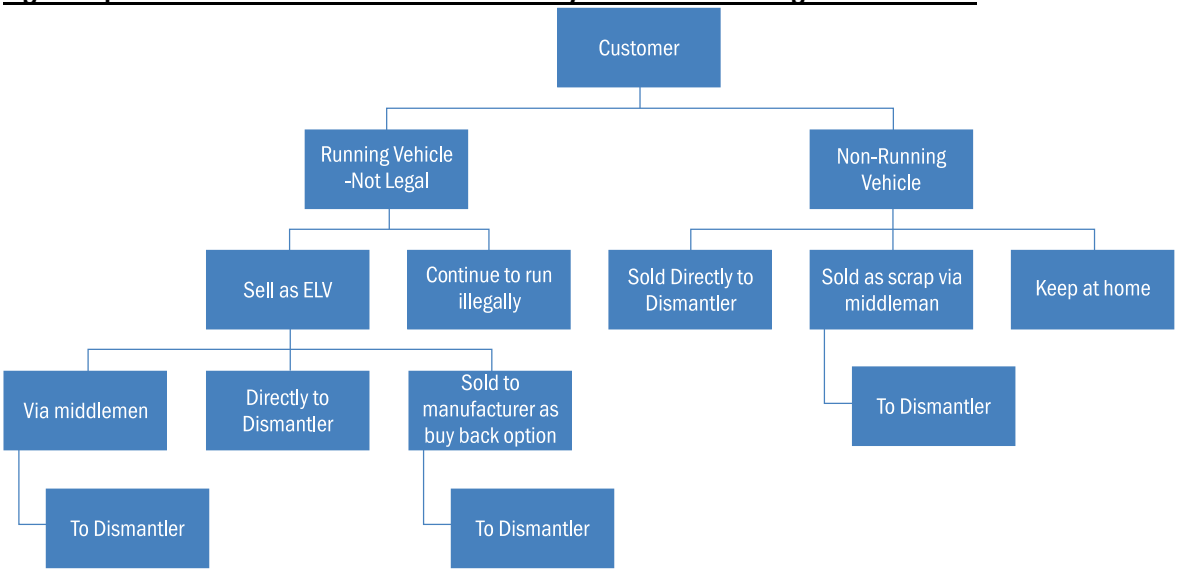
Considering the quantum of resources that could be recovered from existing end-of –life vehicles, it becomes pivotal to understand how the system of ELV management can help in this recovery. Understanding the existing ELV system would be extremely crucial to build a robust mechanism which can handle the huge volume of vehicles which are expected to retire and engage in sustainable ELV management.

Existing System of End of Life Vehicle (ELV) Recovery in India - *A SWOT Analysis*

A vehicle, both commercial and private, is registered for 15 years in India. Some state governments also collect a lifetime of road tax[10] linked to this registration. However, even after the vehicle has reached its end of life, vehicle owners have many options. The owner can continue to run it illegally, sell it to another user,[11] keep it parked at free spaces, and/or sell them to a dismantler who operates mostly in the informal sector (without getting to know what happens to its parts and components). Another channel that the consumer could use for getting rid of ELVs is to exchange it with a new vehicle under the buyback option offered by the car dealers.

The government is also working towards a legislation to bring in producer responsibility that would make it mandatory for automakers and their agents to buy old and un-roadworthy vehicles and recycle them. The producers could exercise this responsibility with the help of the dealers. This may open another channel where the vehicle owners could go sell their end-of-life vehicles. It is important to note here that in some of the developed countries (for example, in Japan), there is no physical buyback of the vehicles by the producers (OEMs), but these OEMs are responsible for sourcing back of only three revenue-negative components-CFs, airbags, and shredder residues, for which they charge a cess and take help from specialized agencies that collect these components.

Figure 1 presents an illustration of the current system of ELV management in India



[10] It has also been suggested by SIAM that this tax should be discontinued in public interest as it does not serve any major purpose including traceability of the vehicle. We would particularly like to acknowledge some of the valuable inputs received from Captain Mohan Ram, Consultant to TVS Motor Company and Chairman, SIAM Recycling Group which have helped us structure some aspects of the proposed sustainable ELV recovery and management system/business model.

[11] Many of these vehicles (i.e., those that should have been scrapped, as per the government requirement) are instead sold to rural areas or to the second-hand market.

The dismantling that takes place in the informal sector is crude and focuses on component reuse which are economically viable. However there is a need to prevent wastage of resources such as glass, brake oil, coolant, etc. These are simply discarded as they fetch marginal or no value, and there are hardly any storage systems available currently. There is also no depollution procedure being followed in most of these informal scrap yards, and the hazardous fluids from the ELVs are spilled and disposed of on the ground where the ELVs are handled. In such units, the whole area is often contaminated with oil, coolants, and other fluids. Toxic gases such as AC gas are released into the air generating several environmental hazards and occupational safety hazards. AIS 129 tries to address some of these concerns and specifically provides a list of materials that should not be used in vehicles. It also lays down the type of information that vehicle manufacturers should make available to the dismantling centres; sets targets for the minimum reuse and recycling or reuse and recovery rates of vehicles; and makes provisions for the type of vehicles with regard to their reusability, recyclability, and recoverability. But in the overall picture of ELV management, these standards could be revised to integrate the concept of circularity and 'closing the loop' aspects of sustainability. What is required is the development of the AIS 129 standards into a regulatory framework in order to ensure compliance by the informal sector, where much of the recycling is done.

Moreover, issues over the lack of standard operating procedures, ambiguity in deregistration of vehicles, and poorly informed consumer practices prevent effective and sustainable ELV management. While some aspects of ELV recycling are addressed by vehicular policy, environmental policy, as well as the different wastes management rules in the country, other aspects have not yet been covered by any of these existing legislations. Recently, the Central Pollution Control Board (CPCB) of India has come out with "Guidelines for Environmentally Sound Management (ESM) of ELVs" with an objective to regulate the sector. These guidelines advocate disposing of ELVs in an environmentally friendly manner and recommend a system of "shared responsibility" involving all stakeholders—the government, manufacturers, recyclers, dealers, insurers, and consumers. Further, the Government of India under the Ministry of Road Transport and Highways is currently drafting a new scrapping policy or end-of-life policy which is expected to provide incentives to the owner of the vehicle for surrendering an old polluting vehicle and open new avenues for scrap recycling in India.
The authors have tried to evaluate the common strengths, weaknesses, opportunities and threats of the current ELV practices in India based on the existing ELV system. SWOT analysis will enable us to build up on the strengths, address the weaknesses, mitigate the threats and tap the opportunities for supporting a circular economy in the ELV management in India. Table 2 presents the SWOT analysis.

Table 2: SWOT Analysis of existing ELV Management in India

Strengths:	Weakness
1. National Legislations and Guidelines exist a. CPCB Guidelines on Environmentally Sound Management (ESM) of ELVs for proper handling of ELVs at every stage, setting up of a 'Shared Responsibility' scheme and for the development of an enabling policy framework. b. Automotive Industry Standards for End-of- Life Vehicles (AIS 129) prepared to provide guidance for the collection and dismantling of ELVs by authorized centres and describing provisions that manufacturers should take in order to increase the recyclability of vehicles. Although, this remains an important step towards filing the gap, these standards need to be further developed into a regulatory framework in order to ensure compliance. c. Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016 that emphasize on the utilization of hazardous and other wastes as a resource or after pre-processing either for co-processing or for any other use. **2. Surrendering ELV** a. Terminal life policy for commercial vehicles along with incentives for replacement for such vehicles.	**1. Weak regulatory framework** a. Lack of standard definition for ELVs- -a vehicle which at the discretion of its last owner is ready to be scrapped, by the AIS 129Customers are reluctant to declare their vehicles as ELVs[12], affecting the economic viability of recycling processing units.. b. Absence of regulatory framework linked to CPCB Guidelines and AIS 129 standards prevents compliance by the informal sector, where much of the recycling is done. c. Lack of regulations pertaining to automotive aftermarket to bring in minimum quality and qualification criteria for repair, service and spare parts. 2. **Poor Collection network/system including absence of a take back system** a. Existing collection network for ELVs is very informal and there is no institutional structure linked to it. 3. AIS 129 do not provide for a take back system on the part of vehicle producers, resulting in poor logistical arrangement for collection and transportation of ELVs thereby resulting in fragmented recycling hubs 4. **Low salvage price for ELV offered by the formal sector** compared to the informal sector. 5. Informal ways of recycling leads to low raw material re**covery, occupational and safety hazards and contribute**s to increased GHG emission. 6. Limited participation by local authorities, OEMs and dealers in the consumer information campaign elaborating on the need for ELV management. 7. **No Auto shredder facility:** Car hulks left after the dismantling process not being processed, implying secondary raw material getting wasted , which otherwise could have been processed in the shredder. Thus increased percentage of the total ELV mass going into the landfills. **8. Absence of Information management system**: No database for tracking the number of end of life vehicles and their movement.
Threats	**Opportunities**
1. **Environmental and health threats:** No scientific procedures being followed for de-polluting posing serious environmental and health threats. 2. **No discussions with respect to post shredder treatment/technologies leading to increased amount of waste going to landfills.** In countries with legislative ELV recycling systems that mandate a target recycling rate of 95 %, ASR treatment is an important process to achieve this. Moreover in absence of recycling/recovery targets, secondary recovery of ASR, Direct ASR-to-energy applications and Thermo-chemical treatment of ASR not being done.	1. **Legislation and Guidelines:** Under the Hazardous and other wastes (Management and transboundary movement) rules, 2016, automobile manufacturers could frame the Standard Operating Procedures (SOPs) with respect to recycling of Waste Pneumatic Tyres/ tyre Scrap, Used PET Bottle Scrap, Lead scrap/used lead batteries, Recovery of Tyre Pyrolysis Oil (TPO) from tyre scrap. These SOPs will enhance efficiency in the recycling process. 2. **Some existing momentum linked to setting up of scientific and safe dismantling facilities**: a. In 2011, NATRIP facility, which is an automobile dismantling center was setup at Oragadam, near Chennai. It facilitates

[12] Since the opportunity cost of retaining the old vehicle by the owner may not be very high—in fact, the vehicle may serve the owner well in terms of use for shorter distances—many vehicle owners do not discard their unroadworthy vehicles and so these vehicles may never formally reach their end of life. If they do decide to declare their vehicle as redundant, the scrapping allowance they would get by selling the vehicle to the informal sector is more than what they would get from a formal dismantling facility. The reason for this is that the cost of operations in the informal sector (where no occupational and health safety guidelines are followed) is very low as they do not internalize any social and environmental costs.

3. **High-investment costs for establishing** a reverse-logistics network, costs related to quality-assurance test equipment, and costs linked to complicated dismantling as originally, the product was not designed to be disassembled easily for reuse, remanufacturing, or recycling. These challenges can cause businesses invested in reuse, remanufacturing, and recycling of ELVs to fail. 4. **Huge investment is required for setting up of systemized and environment friendly dismantling units**/recycling centers. 5. **Lack of cooperation** between local authorities and other stakeholders	recycling activities, ensuring that all the recovered material is reused by the auto industry. However this facility needs to be upscaled and similar facilities needed to be setup in different parts of the country. b. Recently Mahindra Intertrade Ltd, a unit of Mahindra and Mahindra Ltd, has signed an agreement with state-run MSTC Ltd to set up India's first auto shredding facility, which will be equipped with fully automated end-of-life vehicle recycling equipment and innovative ways that will contribute to the efficient recycling of scrapped automobiles. Need to capture interest. c. Huge volume of ELVs coming up- Estimates suggest that that more than 8.7 million vehicles have reached the end-of-life phase by 2015. The quantum of resources that could be recovered will make the processing units economically viable. 3. **Huge informal sector**: a. Presence of a large informal sector engaged in ELV handling and dismantling. Basic Technical know-how and years of experience among informal recyclers, implying with limited training they could be absorbed in the formal setup. Resulting in new permanent jobs. b. Establishing network of reverse logistics that incorporates informal sector activity would enable capturing material value after use, and prevents health risks for dismantlers. This would also give manufacturers a reliable and economical supply of raw materials. 3. **Zero effect – Zero Defect programme of ACMA:** The cluster programme aims at making participating auto component companies globally competitive which would involve leading them to achieve targets of Zero Defect, have environmentally efficient systems and devise mechanism to protect environment for future generations 4. Leveraging the opportunity to generate environmental and health protection benefits , informal sector workers can be trained , awareness created and economical access provided for the necessary equipment and technology for the safe and efficient dismantling of the auto components for the end-of-life vehicle management. Doing so will serve the dual objective of addressing the hazardous working conditions prevalent in the informal sector and increasing the cost of informal dismantlers thereby incentivizing environmentally sound and economically viable recycling units to become price competitive

Learning from across the World

The European Union (EU), Japan, Korea, and Taiwan present examples of countries that have a product oriented legislation to control the recovery of ELVs. These countries have recognized that a distinct ELV law is necessary within the framework of the extended producer responsibility (EPR) framework and have reported success in controlling the number of ELVs off the road. Also, with the evolving global environmental awareness, shrinkage in the availability of landfill areas, and depletion of natural resources, these countries have designed strategies towards product recovery. With the help of present learning and experiences from these countries, inputs can be collated to design the recovery and sustainable management of end-of-life vehicles for India. Table 3 presents a cross country comparison of ELV management systems.

Table 3: Comparison of ELV management system between countries

Details	Taiwan	China	Korea	Japan	Canada	Singapore	European Union	India
Government Involvement / ELV Legislation Act	Waste Disposal Act	Statue 307 law on ELV	Law: The act for resource recycling of electronics and automobiles	End of life vehicle recycling law	None (Voluntary)	Vehicle quota system	Law Directive 2000/53/EC Of The European Parliament And Of The Council of 18 September 2000 on end-of life vehicles	No law CPCB guidelines
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		At the discretion of last owner
Consumer Awareness*	Present	-	Present As a part of EPR manufacturer disseminates information	Present	Present	-	Present As a part of EPR manufacturer disseminates information	Not Present
Databases on end-of life vehicles and their treatment	Yes	-	Yes	Yes	Yes	-	Yes	No
Collection system for procuring ELV	Manufacturer responsibility exercised via service stations or car dealers	collected by designated take back systems operated by dismantlers or service (OEM) or vehicle manufacturers	Collection agencies/Recycling centres	Manufacturer via Dealership network which then transfers ELVs to the authorized treatment facilities	Automotive Recyclers in Canada (ARC) with the support of the Canadian Vehicle Manufacturers' Association (CVMA)	No manufacturer involvement	Manufacturer and importer responsibility Establishment of ELV collection and recycling network	Largely through the informal sector
Recycling fees paid by	Manufacturer and importer when purchased	Market driven (collector pays the last owner)	Market driven (collector pays the last owner)	Deposited by users New vehicles: deposited at time of sale Old vehicles: deposited at	Market driven (collector pays the last owner)	Market driven (collector pays the last owner)	Producer incurs the recycling cost	Market driven (collector pays the last owner)

				time of automobile inspection				
Recycling centres/Operator size	303 recycling operators, 5 shredding and sorting plants	367 recycling operators, 1 pilot recycling centre	226 recycling operators, 7 shredding and sorting plants	5000 recycling operators, 140 shredding and sorting plants	-	-	Number varies across member countries	Largely by unorganised sector
Effective recovery rate	95%	No target rate Possibility of recycling: 2010: about 85 % (material recycling of 80 % or more) 2012: about 90 % (material recycling of 80 % or more) 2017: about 95 % (material recycling of 85 % or more)	Until 2014: Material + energy recovery: 85 % (of which energy recovery rate is within 5 %) After 2015: Material + energy recovery: 95 % (of which energy recovery rate is within 10 %)	95%	-	-	Until 2006: Reuse + Recovery: 85 % Reuse + Recycle: 80 % Until 2015: Reuse + Recovery: 95 % Reuse +Recycle: 85 %	low
Incinerator**	Used	Set a developmental goal for energy recovery: Recently started using incinerator (though information not available about its functionality)	Used	Used, Banned landfill dumping of ASR	-	-	Used	NA

Source: Adapted from Ahmed, S. et.al 2014, Azmi, M. et.al 2013, Directive 2000/53/EC of the European Parliament on end-of life vehicles, Yi Cho-Hwa et.al 2015, Hua-Shan Tai et.al 2015, Sakai. et.al 2014, Ming. C 2012, KC Chen. et.al. 2010, Chen. M (2005), CLEPA Material Regulation event, Solid waste& Recycling Canada.

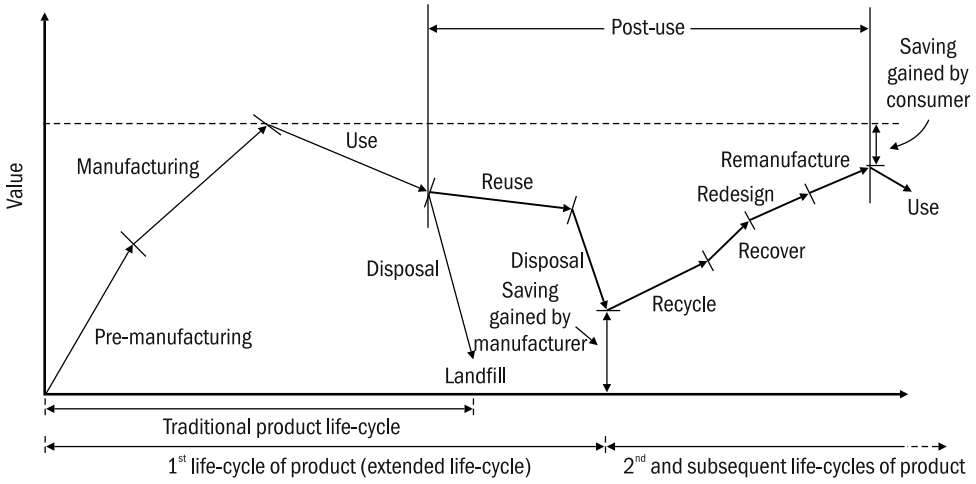
** Collection and/or disposal fee levied on the owner is taken as a proxy indicator for consumer awareness, where there is no direct information available on whether consumer awareness exists or not*

*** Recycling/ processing ASR for energy recovery is taken as a proxy indicator of incinerator being used*

Sustainable ELV Recovery and Management System/Business Model: A Proposed Framework

In this section, the authors propose a framework based on shared responsibility approach for sustainable ELV recovery and management system/business model that can help implement the CPCB guidelines and draws upon the learning from the international practices to build up on the strengths, address the weaknesses, mitigate the threats and tap the opportunities for supporting a circular economy in the ELV management in India.. This system, in addition to preserving the environment, focuses on the stakeholder's engagement required in generating economic profitability and social benefits. This paper ideates that the integration of the 6R (reduce, remanufacture, reuse, recover, recycle, and redesign) principles of sustainable manufacturing would provide the essential elements to ensure the creation of a circular economy. Saman *et al* (2012) illustrates (Figure 2) that a 6R framework when applied to the automotive Industry will yield savings both for the manufacturer and the consumer. The authors demonstrate that an elongated use phase of the vehicle not only delays the death of the vehicle but allows the reuse of parts which are in working condition (and do not create any safety issues). Moreover on effective disposal, recyclable material can re-enter the production territory and assessment against the recovery target is done. In presence of failure to meet the target, manufacturers will have to consider redesigning of the vehicle to enable easier and efficient dismantling, thereby enhancing the recovery rate. Easy and simple dismantling will also enhance the recovery of parts which could be used for remanufacturing of vehicles. The saving of energy, labour and raw material, retaining of value and decline in waste will bring down the costs for the consumers.

Figure 2: 6R framework applied to automotive industry



Source: *Saman et.al (2012)*

The vehicles, parts and components during end-of-life vehicle management, can also be used in the market for repurposing (e.g., electric car batteries used for wind turbine electricity storage), upcycling (e.g., designers producing consumer goods from parts), and down cycling (e.g., shredding and mechanical separations of parts not suitable for any other purpose). Here the emphasis should be on reuse, considered the most important, in product recovery. Reusing 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, needs to be done. But in the current Indian scenario of substandard units, refurbishing worn-out parts and machinery without proper concern for metallurgy, fatigue, or testing can make it a risky proposition to drive vehicles that have these parts. Table 4 presents the integration of the 6R concept in the responsibilities of the

different stakeholders in sustainable ELV recovery and management system/business model. Now we elaborate on stakeholders responsibility for implementing the proposed framework.

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

Activity	Responsibility	Explanation
Reduce	Manufacturer	Reduce material variability
Reuse	Part dealers/manufacturer	Sale of reusable parts collected from the dismantling process
Recycle	Recyclers	Recycle used materials as raw material for manufacturers/other use
Remanufacture	Remanufacturer	Damaged parts which are still usable will be remanufactured by OEM
Redesign	Manufacturer	Design parts for easier and efficient ELV dismantling
Recover	Incinerator	Regain the energy embedded in the material

Source: *Adapted from Azmi et.al 2013*

Manufacturer Responsibility: During the Design Stage

The increasing change in materials composition (for example, the increase in the fraction of plastic and aluminium) of modern vehicles can create new problems in ELV management. Recycling plastic is very difficult when it is present in small parts or is attached to another material. Similarly, recycling aluminium is not straightforward due to its presence mostly in the form of alloys. It is also important to note that the technique of disassembly and recycling will vary across materials. Thus the choice of material is one of the key elements in designing vehicles and will play an important role for sustainable management of ELVs. The main responsibility of the manufacturer during the design stage would include:

- Design for disassembly;
- Adopt material substitution and increase the usage of less-toxic metals;
- Identify materials using standard labeling systems; manufacturers and importers of cars should label parts and provide manuals for disassembly to auto recyclers;
- Have a design for vehicles which is receptive to using recycled/secondary raw material which also reduces chances of downcycling. Specifically, the design could be based on end-of-life criteria while taking into account the age of the vehicle, emission norms, and technology status. In the process, the manufacturer could try getting a competitive advantage by working towards a design that not only optimizes on using resources and recoverability of resources at the end of life, but also that extends the life of the vehicle, thereby delaying its redundancy and death.

Manufacturer Responsibility: At the time of sale

Pay a transparent Advance Recycling Fee (ARF) to the ELV fund wherein the fee can be designed within the framework of the following factors:

- Linked to the rating achieved by the vehicle with respect to the index/label for the recovery and recyclability of resources at the end of the vehicle's life and as per the vehicle's class.
- Should cover part (say about 50%) of the rough estimated ELV management cost (excluding the transportation cost of bringing the vehicle from the last user to the dismantling centre). The rest of the cost could be recovered in full or piecemeal from the owner of the vehicle. However stakeholders could be consulted to arrive at the exact percentage of the price of the vehicle which could be charged as the ARF.

Dealers' Responsibility

Franchised dealers serve as an important channel linking the manufacturer and the buyer of the vehicle. They have significant potential in encouraging the sourcing back of the ELVs and this is the stage at which they can be specifically encouraged to exercise their responsibility for ELV management.

- These dealers could serve an additional function as accredited units that are authorized to collect and recycle vehicles.
- During the sale of a new vehicle, include a guidance document in the vehicle kit that elaborates on the need for ELV management and ways in which the owner/buyer of the automobile could act responsibly when their vehicle reaches its end of life.
- Collect the ELV cess which is levied on the owner and has to be paid upfront at the time of purchase. The dealer will also have to deposit the cess collected into the ELV fund. This cess will later be refunded to the owner when he takes his ELV for deregistration.
- Enter into an agreement with the owner of the ELV who is exchanging his ELV for the new vehicle whereby the dealer promises to handover the "Certificate of Destruction" and/or "Certificate of Deregistration" to the owner on a postdated basis. Also, dealers may retain a part of the ELV cess as payment for deregistration on behalf of the last owner.
- Enter into tie-ups with tow truck operators and offer fee-based services to do an immediate[13] transfer of the ELVs that they have received (in exchange for sale of their new vehicles) to the Regional Transport Offices (RTO) or to any authorized treatment facility, whichever is convenient.

Last Owner's Responsibility

The last car owners (i.e., users) are the starting point of the ELV chain and should have the responsibility to ensure that the vehicle gets deregistered. The various channels that could be explored for this are:

Surrendering the car at the RTO

- The owner takes the ELV to the RTO (which later sends the vehicle to an authorized treatment facility), that is also authorized to act as a designated collection point. The RTO then legally issues a "Certificate of Destruction" and/or "Certificate of Deregistration" with all the paperwork related to the surrendering of the car being completed on its premises. These collection points are at the customer front end and there would be such multiple points in a metro city.

- Based on the rate list that is published by the RTO, the owner gets paid a price for the ELV. This rate list could be arrived at by consulting the vehicle manufacturers, and focusing on the revenue streams, and cost flows which suit the target value of the recycling process. The rate list should also have a differentiated element linked to the condition of the cars and the extent of usable parts (that can be assessed after an inspection of the vehicle's physical condition). However, it is important to make a distinction here between the rate list for vehicles which are already plying on roads (and do not have any advance recycling fees deposited against them into the ELV fund) and those which will be sold once this proposed framework gets implemented (in which case, for all new vehicles sold, there would be an advance recycling fees collected at the time of sale of the vehicle, in part paid by the manufacturer when he sells to the dealer and in part paid by the buyer of the vehicle is purchased from the dealer). This will be a way to exercise the shared responsibility.

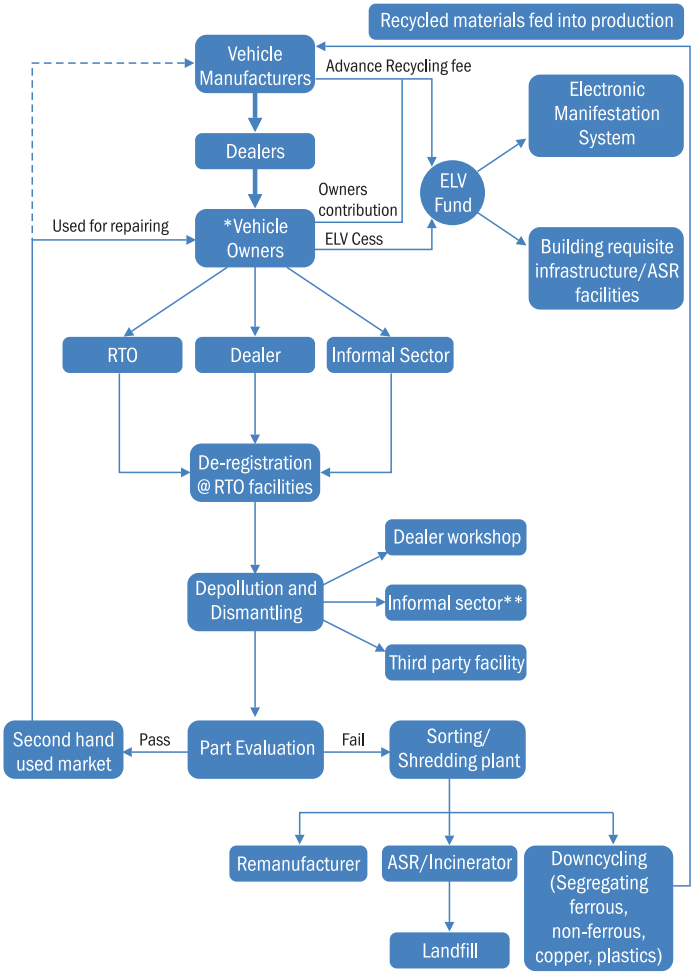
Surrendering the car at the dealer's in exchange for a new car

[13] Since dealers mostly do not have much space nor do they have the required staff to deal with ELVs at their premises, it is important that the transfer from their premises is immediate. Moreover, most dealers also operate from their showrooms located in the heart of the city.

- The owner takes the ELV vehicle to the vehicle dealer from whom he is buying a new vehicle and exchanges his old vehicle for the new vehicle. The dealer promises to handover a "Certificate of Destruction" and/or a "Certificate of Deregistration" to the owner on a postdated basis (since the dealer has to get the certificate issued from the RTO or an authorized treatment facility after surrendering the car there). For example, this certificate can be handed over to the owner when he comes back to the dealer for his first service. The salvage price of the ELV is adjusted in the price of the new car which the owner is buying in exchange of his ELV. The RTO then sends the car to the authorized treatment facility.

Note: The salvage price that is which is globally offered to the owner to pay the cost of vehicle's steel. For bringing about a behavioral change in Indian consumers, a markup over the price of steel could be considered. The suggested additional responsibility of the RTO as a collector in our proposed framework (Figure 3) is a short-term measure that will help in giving impetus to the whole process of formal ELV management by providing people with a convenient option to go to and surrender their vehicles. But in the long run, as in most EU member states, vehicle manufacturers and importers should be made responsible for setting-up national collection networks for the collection of all ELVs.[14] In collective schemes, a Producer Responsibility Organization (PRO) could be set to implement the EPR principle on behalf of all adhering companies (the obligated industry). In the Indian context, manufacturers could exercise their responsibility via dealers.

Figure 3: Proposed framework for Sustainable ELV Management



[14] Source: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52007SC1348

* Owner of vehicle reaching end of life.

****** **To continue in the short run.**

------ **Some material could be used by auto component manufacturers, once they start re-manufacturing.**

Authorized treatment facility (ATF) Operators responsibility

ATFs—more commonly referred to as dismantlers, scrap yards, salvage yards, or breakers yards—are sites that have been licensed to accept waste motor vehicles, store it till the vehicles are dismantled and then undertake the dismantling, recycling, and treatment process complying with the requirements of the ELV regulations. The facility also has the capacity to do the depollution. The main purpose of the depollution is to remove all hazardous materials from the vehicle and safely dispose of them. It is important to highlight here that the ELVs may at times have certain reusable parts. These parts can be separated at the depollution unit and can be sold out in retails or can also be used by part dealers (Arora, 2017).

The facility needs to ensure there is optimal dismantling done prior to shredding with the goal of increasing materials recovery, reducing shredder residue volumes, and reducing contaminants. Specifically, the dismantling needs to:

- Increase the number and amount of materials and parts that can be removed;
- Source the recovered parts to a market for reuse;
- Sort, save, and send defective and damaged parts for recycling;
- Recover automotive fluids from defective and damaged parts and send them for recycling.

Dismantling can enable the recovery of up to roughly 40% of the total ELV weight for reuse as spare parts and for recycling of large metal and plastic components. Some of the liquids and parts from the depollution stage can also be reused, for example, fuel. Other parts, such as engines, batteries, and electronic components are potentially reusable depending on their age and state of repair. Electric and electronic components which cannot be reused need to be dismantled due to their toxic content. In some cases, materials of high value, such as copper wires and platinum from catalytic converters are also collected prior to shredding.

Post dismantling, the parts which are not fit for reuse or remanufacturing are sent to a shredding plant. The purpose of shredding is to segregate materials for recycling. The material is first shredded in a few square inch sizes and then segregated as iron, aluminum, copper, plastics, glass, land fill, and other forms. With up to 90% of the ELV weight being shredded, post shredder sorting is a crucial process to recycle and recover materials. After the shredding process, dense media can be separated from the light ASR, or Shredder Light Fraction (SLF), using an air classifier. Magnetic separation can then be used to remove the ferrous fraction, non-ferrous materials, and plastics. Materials that can be recycled are then sent to manufacturers. The remaining light and heavy ASR fractions are then sent to energy recovery and landfills. Box 2 suggests two ways in which a treatment facility can be structured.

Options for structuring the Authorized Treatment Facility (ATF)

Option 1: One comprehensive facility which has a depolluting unit, dismantling facility, recycling space, and shredding machinery all in one place. In the current situation in Indian cities, this facility will need to come up. Third-party involvement could play an important role in setting up the facility.

Option 2: ATF could have segments spread across with close connects and tie-ups. These tie-ups also need to integrate the informal sector such as the Mayapuri in North Delhi. Additionally, this structure could explore the possibility of carrying out dismantling at the various large vehicle service stations/workshops that are spread across the cities. After the dismantling, dealers will have reusable parts, which they can either sent to the manufacturer and/or retain some parts and use it for servicing and repairing works and/or sell them in the secondary market.

It is important to highlight here that the National Automotive Testing and R&D Infrastructure Project (NATRIP) [15]facilities would be crucial for training personnel who could then engage in scientific dismantling and work at the ATFs thereby leading to better resource recovery.

Institutional Support Required from the Government

1. Defining ELVs: One fundamental impediment gets reflected in the way ELVs are defined. One way would be to use a combination of 2 factors- the age of the vehicle (say greater than 10 years) and the road worthiness (PUC + testing for road safety) of the vehicle. So for a vehicle which is more than 10 years old and has failed the road worthiness test twice consecutively, then it should be declared as an ELV. However, if a vehicle which is less than 10 years old but has failed the road worthiness test twice should be subject to deeper investigation to identify the reasons for failure.

2. Encouraging Declaration of ELV:

- Make it mandatory to obtain a 'Certificate of destruction', which certifies that the owner has brought his ELV for de-registration. This will remain a pre-requisite for getting ELV cess refunded. Once the car reaches its end of life and it does not get deregistered, the vehicle owner faces a penalty. Random checks by the transport policy officials can be used to assign credibility to the levying of penalty. For existing ELVs, RTOs can also notify the vehicle owners to get their ELVs deregistered.

- Increasing road tax on re-registration of vehicles, dis-incentivising re-registration when the vehicle is close to its end of life.

- The RTO database overtime can also be strengthened to create a mapping of vehicles with its owners and financers ensuring that the owners have disposed off their old vehicles (which have reached their end of life) before they have bought their new vehicles.

3. Designated Collection Points: Regional Transport Offices (RTOs) should be allowed to also operate as Designated Collection Points that legally issues a "Certificate of Destruction" and/or 'Certificate of Deregistration' and then transfers them to accredited dismantling facilities or authorized treatment facility and/or manufacturer owned and operated collection and treatment facilities. The cost of the logistics could be borne out of the ELV fund. Over time, vehicle manufacturers could be mandated to set up collection facilities

4. Infrastructure support: Land for setting up requisite infrastructure including auto shredder facilities. Here Government could initially waive off the rental for few initial years, and overtime when the facility becomes economically viable, reasonable/ market rent could be laid. The current informal sector engaged in the ELV management could be relocated to this land, away from the residential areas and having to meet the minimum hygiene standards such as the impervious floor, etc. detailed in AIS129.

5. Setting up of Automotive Recycling Promotion Centre (ARPC): This needs to be a nongovernmental body which acts as regulator as well as an auditor for ELV recycling operators. This body also manages the ELV Fund; they are required to provide monetary incentive (refunding ELV cess) for owners who wish to surrender their vehicle for scrapping. It also monitors the functioning of electronic manifestation system which helps in regulating by keeping a record of ELV movement at various stages- when a vehicle gets deregistered, where is it depolluted, where it gets dismantled and so

[15] www.natrip.in

on. ARPC would develop an overall index/label indicating the recovery and recyclability of resources at the end of life of the vehicle.

6. Benchmarks/Certification / Labeling/Targets:
(a) Quality standard for secondary raw material will help in creating the market for secondary resources. Further such standards could be used to develop efficiency targets which require the use of a certain percentage of recyclable materials in new cars as part of a shift to emphasizing design for the environment.
(b) Setting up minimum benchmark requirements that informal sector needs to follow for carrying operation (safe disposal of toxic gases, oils, glass, puncturing the engine if the vehicle has reached its ELV, health and safety needs of the informal sector). Moreover designing social
security incentives for informal labourers could be considered.
(c) Ban materials such as tires, windshield glass and polypropylene plastic going into the landfills, and/or impose high taxes on landfilled shredder residue in order to ensure that recycling targets are met and there is minimization of shredder residue

7. Awareness generation: There needs to be emphasized awareness created for the labourers
about the adverse health outcomes if they continue to operate in the crude manner. Abiding by the occupational and health safety standards will increase the cost of operations of the informal sector and they may not then be able to offer the relatively high prices they currently do to the last owner for retiring their old vehicles. But this would certainly help bolster our efforts towards integrating the informal sector into a formal set generating social and economic benefits for them in addition to creating environmental benefits for the society in terms of reduction of pollution generated through their informal ways of operation and ensuring higher recovery rate of resources from the ELVs.

Conclusion

One of the major issues that the world is currently grappling with is the unprecedented growth in the demand for various resources and the associated challenge in meeting the demand. Not only is the resource requirement in the making of automobiles significant, but also it is also the potential for recovery of resources for vehicles that are at their end of life. ELV management is important not only because it is a potential source of supply for secondary raw materials, but is also a major step towards reducing carbon footprint. With the government moving towards stringent emission norms, there would be a need to create better and frequent advancements in ELV management. Also, with the government eyeing large-scale implementation of National Electric Mobility Mission 2020, it needs to ensure high-grade recycling capacity with the aim of
recovering lithium, cobalt, and other metals used in traction batteries which is important from an ecological and industry-specific point of view.

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