iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1281

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Evolving an E-Waste Tracking System for India to Mitigate the Problems of E-Waste Management

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Abstract*: *E-waste generally consist of electronic devices and household appliances which have either outlived their life or are no longer of any use. In the past two to three decades, the global market of industrial and electronic equipment has shown exponential growth. Asia has become the engine of world e- waste generation. The e-waste product cycle is not monitored at present leading to scattered non-structured management which poses a threat to economic development. Therefore, it is imperative that an approach for tracking e-waste from manufacturer/producers to the consumers is developed. The concept of tracking e-waste will not only help in keeping a check on the disposal of e-waste but will also help formulating sustainable linkages among the stakeholders and result in safe disposal of e-waste. The tracking of e-waste from the time of purchase until it is taken for recycling would give a clear perspective of supply chain strategies for managing e-waste. The tracking method would allow electronic manufacturers to follow the physical and economical fate of a particular product through appropriate monitoring mechanism. The approach behind this research is to develop a tracking system for waste electrical and electronic equipments (WEEE or e-waste), so that throughout their life cycle, e-waste can be tracked, monitored and recycled/ disposed effectively to mitigate the adverse impacts on the health and environment globally.
Keywords: E-waste, Inventory, Tracking, WEEE, Regulations, Standards, Rules, Channelization

I. INTRODUCTION

The innovative and advanced technologies along with globalization of economy have made electronic products easily accessible and acceptable to people. But due to increase in the consumption of electronic products there is an alarming generation of electronic waste. As correctly put up by RajyaSabha Secretariat [15], changes in technology affect the global mass of e-waste produced. Global e-waste generated in 2014 was around 41.8 million tonnes (MT) has been estimated to reach 50 MT by 2018 with an annual growth rate of 4 to 5%. Among the global regions, Asian region produced the highest amount of e-waste (16 MT or 38% of total), followed by America (11.7 MT) and Europe (11.6 MT). The top three Asia-Pacific countries with the highest e-waste generation in absolute quantities (per year) are China (6 MT), Japan (2.2MT) and India (1.7MT). The top three Asian regions or countries having the highest e-waste generation in relative quantities are: Hong Kong (21.5 kg/inh.), Singapore (19.6 kg/inh.) and Brunei (18.1 kg/inh.) [1]. Hotta et al., 2009 [5] quoted that "Asia has become the engine of world waste generation". In India, the main contribution of electronic waste comes from the government, public and private (industrial) sectors, which accounts for almost 70 per cent of total waste generation. A small portion is also contributed by the individual households which accounts for approximately 15 percent and remaining is added by the manufacturers [14].

In India, there is a huge scope for improving the management of e-waste. It is projected that 75% of electronic items are just stored due to a lack of knowledge of properly managing them [13].The main thought behind storing e-waste is the issue of disposing them as a product on immediate basis [18].Thus, electronic products at the end of useful life remain stored in houses, offices, warehouses, etc., and get normally mixed with household wastes, which are finally discarded with municipal wastes and end up in the landfills [18]. In India due to lack of appropriate management or channelization, e-waste is primarily treated by the unorganized sector [10]. Hence, there is an urgent need of implementation of proper e-waste channelization in India.

II. METHODOLOGY

The study was carried out based on primary and secondary survey. Information collection was undertaken to seek response from various stakeholders with the help of structured questionnaires. In addition, one to one interaction and telephonic interviews were also conducted. Secondary resources such as published articles in public domain, newspaper articles, annual reports of Government departments, technical studies, surveys and opinion were also analyzed and screened for relevant information [19].

The main objective of this paper is to facilitate transparency in Indian context, which in turn will help in identifying a wide range of diverse stakeholders in the e-waste generation. The work protocol of all the stakeholders will provide a facility to trace the status of

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e-waste till the end of life. On the basis of responses of questionnaires and literature review of past research a tracking system is developed for sustainable disposal of e-waste.

III. OBSERVATIONS

The study aims to seek information from various stakeholders by means of using a structured questionnaire and interactions were focused to get information on the degree of compliance. The information was sought from various stakeholders; samples studied for the same are given below.

Contribution of Stakeholders in E-Waste Generation

E-waste generation process comprises of many stakeholders. As per MoEF&CC, 2008 [10] notified rules and regulations, three types of stakeholders that contribute in the generation of e-waste are:

First level: Preliminary E-waste generators.

Second level: Secondary E-waste generators.

Third level: Tertiary E-waste generators.

The contribution to "Preliminary e-waste Generator" arises from formal organized market like Producers or Manufacturers, importers, offices and organized markets, where e-waste from individual consumers is derived either through exchange schemes or as a discarded item. Thus, the main stakeholders are scrap dealers/ dismantlers who buy e-waste from the first level generators in huge quantities. The mentioned stakeholders don't possess large capacity of dismantling and remain tangled in trading of e-waste with" Secondary e-waste Generators". The way of marketing between first and second level is semi-formal i.e. part formal, while the market between second and third level is completely informal [22]. The various stakeholders involved in the e-waste generation is described below

A. Producers and Manufacturers

The producer is responsible for the management of e-waste generated by the end of life products. Essentially the producers use the dealers/distributors /retailers/or any other agency to collect the e-waste for which they may provide certain incentives such as cash incentive offer/voucher and exchange programmes. Producer may also organize a direct take back system for their brand of products from the identified consumers. Take back system may also require an agreement between the consumer and producer to ensure that the end of life product is returned to the producer. The data collected from various producers is presented in figure 1. Twelve producers is providing collection points in the various part of the country, three producers is providing the collection facility along with the dismantler/recyclers and another nine producers is providing individual collection centre facility.

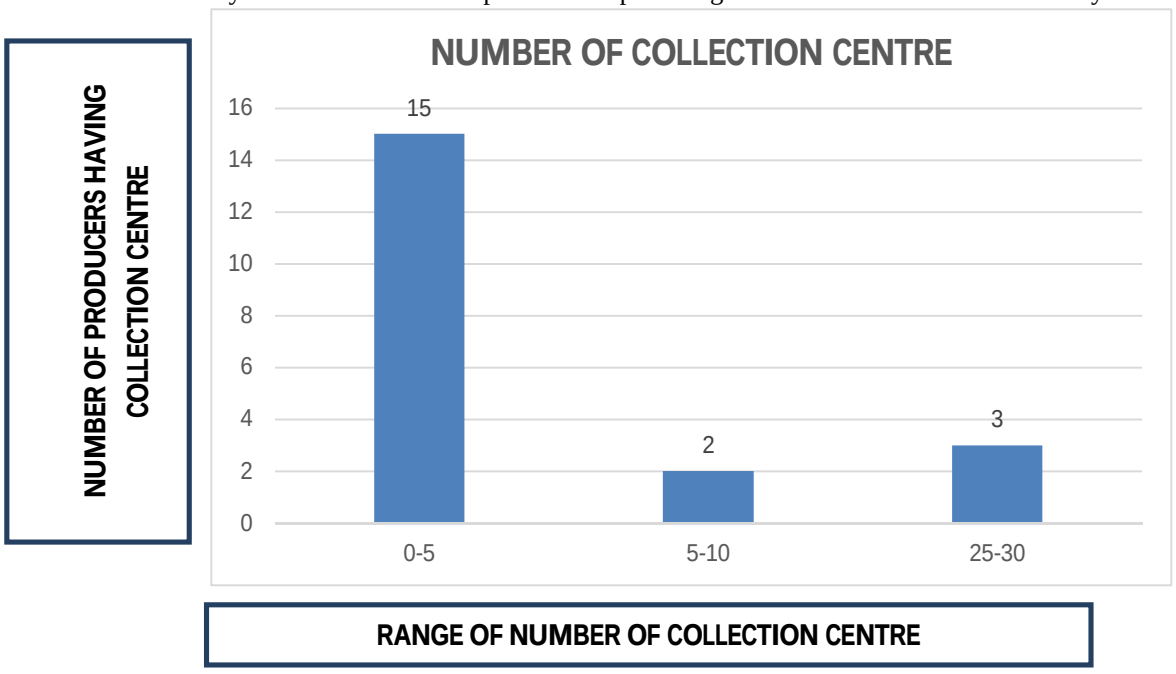

Fig.1 Number ofCollection Centre

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B. Offices (Public, Private, Governments, Business)

The business sector namely government departments, public or private sector, Multinational Corporation (MNC) offices, etc. are the earliest users of IT and IT products and today they account for a considerable amount of total installed ICT equipment [21].To digitise everything from marketing to banking, paperwork in every sector needs to be replaced with computerised banking & marketing systems all across the country. Collected data shows that majority of the desktop computers are out of use as the life span of computers is 5 years only followed by, cell phones, computer peripherals, laptop computers, Modems/Routers, Air conditioners, Printers, Microwave/Oven and Refrigerators.

Bulk consumer has to ensure that the e-waste generated by them have to be channelized to authorized collection centres or registered dismantler or recycler or is returned to the producer through its pick up or take back services or through its collection points. As per the response given in figure 2 majorly (62%) the bulk consumers prefer to give their waste to recyclers, 25 % prefer to sell, 16.6% prefer to donate it in school and give them back to the person who sold it to them, 12.5% prefer auction, 4.17% prefer storage & 4.17% hand it over to *kabadiwalas (informal recyclers).*

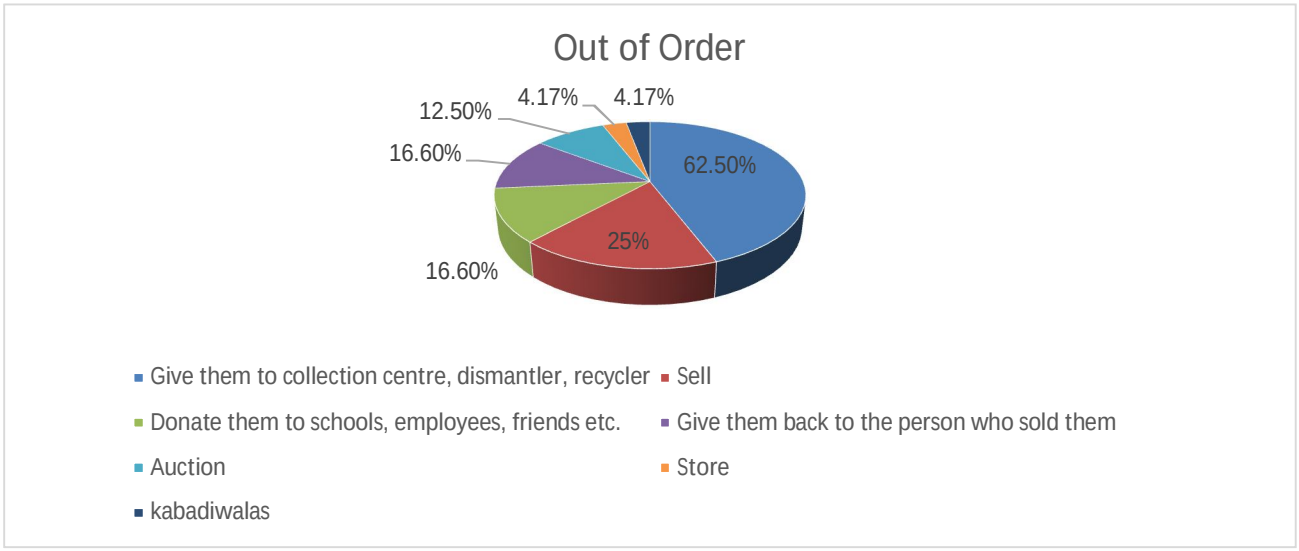

Fig.2Equipment Management

C. Individual Households

The field study indicates that the proportion of contribution from household section is increasing continuously. The middle to high income group society's contribution to e-waste generation is rising rapidly. In the major Indian cities consumers buy EEEs with new and modified feature with the attractive offers, discounts and exchange offers. Moreover, a persistent view of e-waste as a product causes reluctance among people to dispose of e-waste immediately [18]. No effective collection systems have been put in place by the producers other than storing the obsolete products in their warehouses. Most of the used equipments are refurbished and repaired a number of items and many of them are sold in the thriving secondary market. Due to the gap in collection systems, only 40 % of the total e-waste is channelized for recycling while the rest 60% remains untraceable [14].

D. Import of E-waste into India

The import of e-waste is not legal and e-waste is often shipped from developed countries to third countries like China, India or Nigeria [2], [9], [4]. It is estimated about 50,000 tonnes of WEEE are being imported to India every single year. India is becoming a big market for imported e-waste. There is 80% import of e-waste from US and rest 20% is imported from the EU [20], though, the estimated statistics are not precise. Most of the developed countries find it financially suitable to send the e-waste in developing countries for the purpose of reuse and recycling [11].The reason behind sending the e-waste in developing countries is that the recycling cost of a single computer in the United States is $ 20 while in India the cost for the same is only US $ 2, so approx. US $ 18 is saved, if the computer is exported to India [2].

"Secondary e-waste Generators" are those stakeholders who have inadequate economic capacity and are involved in the dismantling and segregation process of items/ components such as dismantling of Cathode Ray Tube, Printed Circuit Board, plastic and glass from e-waste.

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‘‘Tertiary Level Stakeholders” are the main stakeholders between second and third level and these are like scrap dealers, dissemblers/dismantlers, smelters, recyclers, metal extractors, plastic extractors and electronic item extractors. They practice extraction process, which are dangerous in nature. Material extraction involves health and environment hazardous processes like uncontrolled emissions, untreated discharges. Remains of WEEE/E-waste are dumped in open Dump Sites after recycling. The details of tertiary level stakeholders are given below

E. Dismantlers/Recyclers

Dismantlers are those who are engaged in dismantling of used electrical and electronic equipment into their components and the recyclers are involved in recycling and reprocessing of waste electrical and electronic equipment or assemblies or their components having such facilities. Dismantler/recyclers were visited in Delhi/NCR, U.P and Haryana to have estimation about their role. They were asked formal as well as informal questions. The total 37 Questionnaires were filled from the states of Delhi, Haryana, Karnataka, Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, and Uttarakhand. Information was sought using Questionnaire for the same. Response to questionnaires was gathered from site visits, Phone and via electronic mail.

E-Waste (Management and Handling) Rules 2011 come into effect from 1stMay 2012 [11]. As given in figure 3 there is presence of 18 dismantlers/recyclers before the e-waste (management and handling) rules, 2011 and another 19 is introduced after the e-waste (management and handling) rules, 2011.

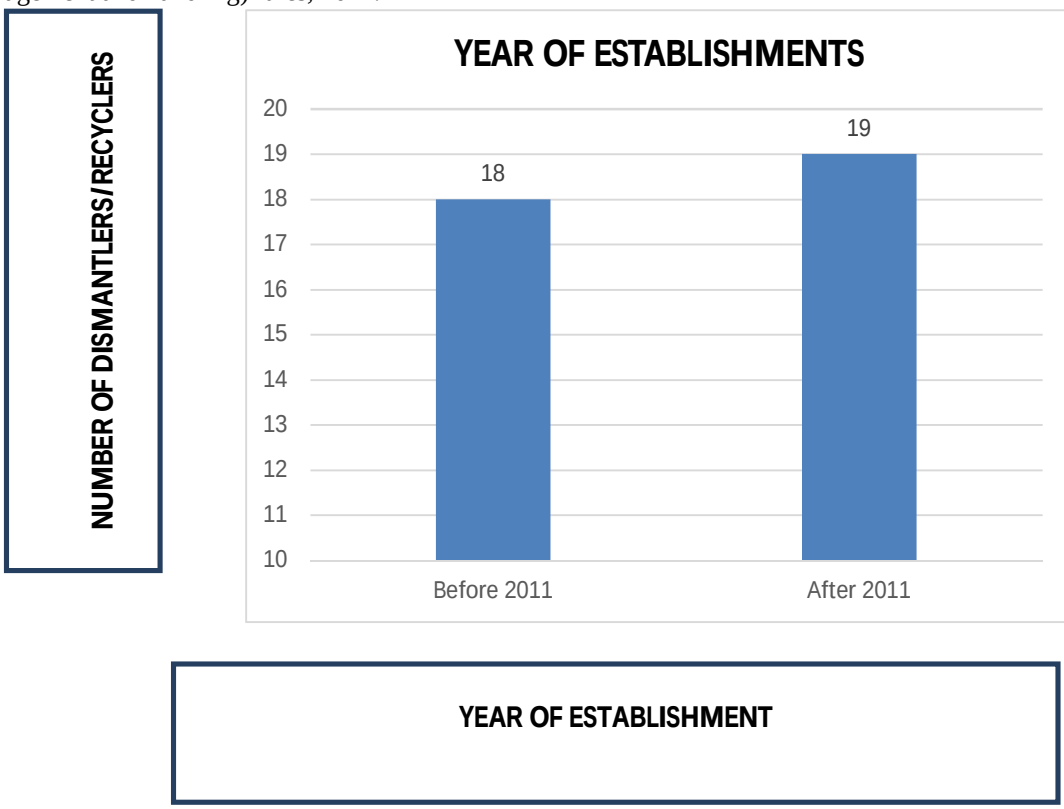

Fig.3Year of Establishments

The major objective of dismantling/recycling operations is reduction of size and separation of steel, plastics, PCBs, non-ferrous metals, glass etc. After reduction, the parts are sent to the recyclers for treatment and recovery of materials. Different activities mentioned in figure 4 are required while treating the electronic waste. As given in figure 4 approx. 70% of dismantler/recyclers have their own collection centre. 100% are doing proper segregation of dismantled e-waste. 46% have the facility for refurbishment & repair, 57% are recycling & recovering the components extracted from e-waste, 35% handover the waste to particular recyclers, 32% utilize the processed e-waste by their own, 32% have bag dust collectors followed by wet (chemical) scrubbers for control of fugitive emissions from furnaces or chemical reactor fumes.

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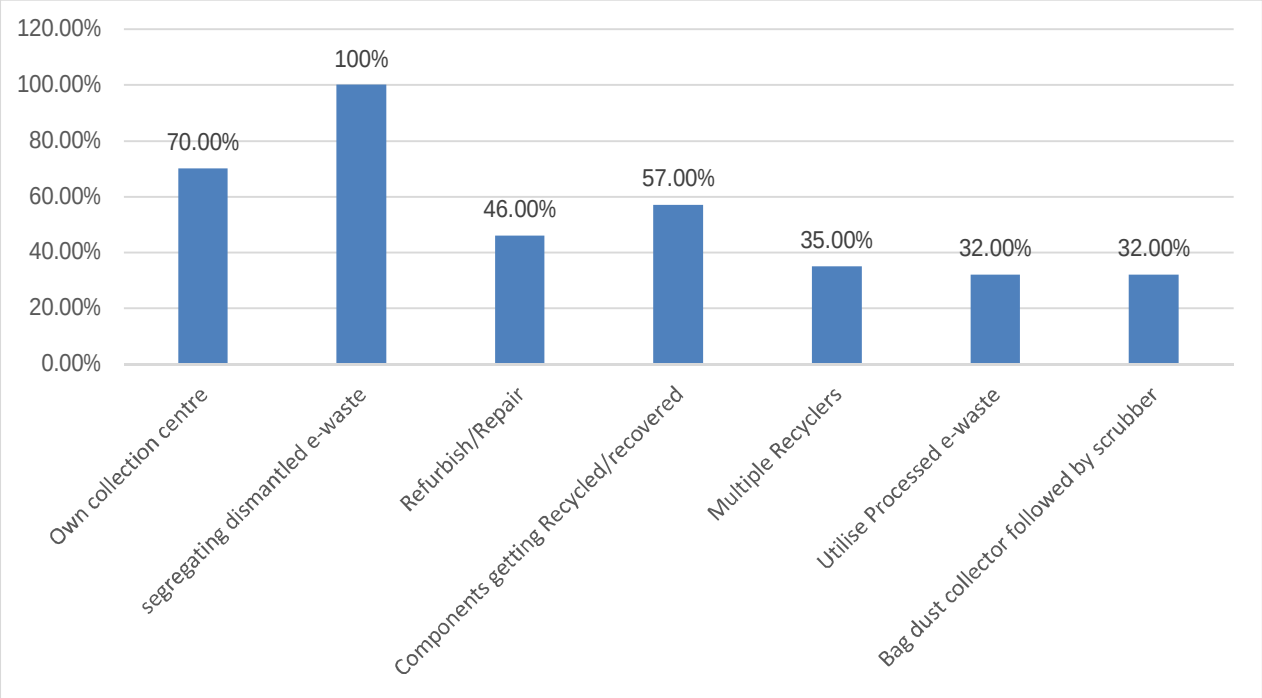

Fig.4 TreatmentFacility

IV. INFORMAL SECTORS

In India, approximately 95% of total e-waste management is handled by informal/ unorganized sector. Information was collected from the informal sector e-waste recyclers in Shastri Park, Mustafabad, Mandoli, Old Seelampur, Jamaluka bag, Mayapuri Industrial Area and Seelampur. This study has been carried out in an effort to assess the e-waste generated and the quantity handled in informal sector.

In India, hawkers also known as Kabadiwalas who contributes majorly in the collection of recyclables including e-waste from the consumers in exchange of money. The e-waste thus collected is sold to the informal sector without any accountability. Therefore, it may be necessary to include and motivate the kabadiwalas and informal sector recyclers to be a part of e-waste value chain by organizing them, to participate in the e-waste collection process [13].

V. DISCUSSION

The aim of the paper is to evolve a tracking system for e-waste management in India. The study of various e-waste tracking systems in developed countries also has been taken into consideration. In the e-waste tracking system practices in countries such as US and Switzerland, it is clear that an effective tracking system can be a potential solution for managing the e-waste problems. The systems of e-waste management in developed countries are discussed in the following section.

A. Electronic waste Management in Switzerland:

There is availability of well-organized management system of e-waste in Switzerland, it is due to the actual collection of e-waste by two Producer Responsibility Organizations (PROs)—SWICO and S.EN.S. The outline of SWICO is to handle 'brown goods'—electronic equipment such as computers, TVs, radios, etc., whereas S.EN.S manages 'white goods' such as washing machines, refrigerators, ovens, etc. From more than a decade SWICO and S.EN.S are handling e-waste, they initiated their e-waste handling on the basis of the principle of Extended Producer Responsibility (EPR), well before it became legally mandatory[8].

The not for-profit S.EN.S system is regulated by a commission comprising of the manufacturers/importers and distributors/wholesalers who conduct meeting twice a year to evaluate the action. The 'SWICO Recycling Guarantee', is again a not-for-profit system, it is regulated by the SWICO Environmental Commission which includes the main concerned person of manufacturers. Main support of both the system is secured financing of the collection and recycling by Advance Recycling Fee (ARF) collected on all the new electronic products.

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The collected money through ARF is utilized for the purpose of collection, transport and recycling of the electronic waste. The implication of ARF fees needs a particular calculation of e-waste generation and number of sales of new products. As of now the use of ARF is successful, but the disadvantage of ARF is that the collected fees may not be enough for recycling. Another disadvantage of ARF is cross subsidization of products between different categories, for example, PC customers give fees for the recycling of tape recorders. For escaping these disadvantages, both SWICO and S.EN.S have different categories of products as per the estimated cost of recycling. The material and financial flows in the system is discussed below [3].

The material flows can be split into two parts – pre consumption and post consumption material flow. Pre consumption material flow includes from the manufacturer/ importer, through the distributor and finally to the customer.

At the end of life product the existing customer can also handover the products to the retailers who are selling the same products or to defined collection points. The process of flow material in both the stages is similar for both the SWICO and S.EN.S. In Switzerland there is availability of 520 collection points by SWICO and S.EN.S and there is also the availability of approx. 7,000 – 10,000 retail locations which have to take back old products free of charge, regardless of the brand or year of manufacture, thus making it comfortable for customers to treat their e-waste at proper locations. The multiple levels of independent controls monitor the process to confirm that the recyclers are keeping the environmental standards.

1) *Monetary Flow:* At the time of selling or importing the products the manufacturers pay the collected ARF to the SWICO or S.EN.S. The collected ARF is moved to the distributors and retailers who consecutively raise the invoice to the customers on the purchase of a new product. The collected fees through ARF are utilized for the collection, transport and mainly for the recycling of the electronic products. As per the law, retailers are required to take back old products, and are not remunerated for this process to the collection points. Retailers transfer the e-waste from the collection points to the dismantling or recycling centre through authorized transporters. The expense utilized for the recycling process is the main cost for both SWICO and S.EN.S. SENS use more than 47% of the ARF in the recycling process whereas SWICO apply 70% of the ARF received in recycling costs [7].
2) *Monitoring of financial and material flows:* It is important to monitor all the stages in material flow. It is the responsibility of manufacturer to submit all the details related to selling of products as well as details of collected ARF. In the same way the retailer combines the sales of the EEE as well as collected ARF. At the post consumption stage, all the activities are being monitored by external auditors including quantity of e-waste transported, as well as quantity and quality of the recycling, emission levels and precautionary measures. There is also a proper control on the illegal import and export of e-waste from Switzerland. There is a list mentioned in Section 3, Article 9 of the ORDEA [17] for the export of products for disposal. The list describes that the exporter should submit the details regarding environmentally friendly recycling of products and has the prior consent regarding the importing country. As per Basel Convention Ban Amendment, Switzerland does not allow the export of e-waste to non-OECD countries [20].

B. Electronic waste Management in the U.S.

In U.S. due to continuous advancement in technology, generation of e-waste is increasing rapidly and it is expected that this trend will continue, which will further result in the increased quantity of generated e-waste. The existing management of e-waste in U.S emphasizes mainly on two aspects.

(1) Disposal of e-waste in landfills [23] and (2) U.S. e-waste exportation [18]. Many organizations are working on management of e-waste., especially in the states which has e-waste regulations, such as California. Still, due to shortage of federal regulations that promote collection, recycle and reuse of e-waste, there is an obstacle for additional improvement across the country. Thus, the shortage of proper e-waste management is the major problem in U.S. Few plans to improve the e-waste management in U.S are discussed below:-

A proposal of deposit-refund system is planned to stimulate the collection of e-waste. The basic idea behind the system is that the customer will deposit a certain amount during the time of buying a product; a variable amount of the same will be refunded to the customer at the end-of-life product. The deposited amount will be utilized for the management of e-waste including transportation and recycling of the product. The competition will occur among the recycling companies to collect the deposit by bidding different amounts of refunds to the customers. The chance of reuse of electronic products is also involved in this process; where customers may even obtain more refund than the deposit paid. The amount of return to the customer will depend on the decision of recycling companies, whether they will select to refurbish or resell the products in lieu of recycling. This idea is supported by a cyber-infrastructure which involves a radio-frequency identification device (RFID) located on the product to track economic and material

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flows. More discussion is required to choose the location of the RFID in the product or the use of more than one RFID for a single product. The inserted device will be essential for the end-of-life product management and arts [6].

The flow of information in the process starts when the customer buys a product. After purchasing the product including the price of product and deposit fee, the retailer will encode the product's RFID mentioning products feature (size, system characteristics, etc.) and transfer the collected information along with the purchase details (e.g., date, point of sale, deposit paid by the customer) to cyber infrastructure. Now it is the responsibility of retailer to transfer the information to the cyber infrastructure, who will restore the details till the time asked by the e-waste disposal company (collection, recycle or reuse companies). At the end of life, when customer wants to discard the products, they will contact an Internet-enabled market, where different companies will suggest the variable degrees of return to the customers. It is essential for the customer to enter the product identification number also the present location of the product to obtain the best available deals in the area. As per the offers presented by the companies, customer will finalize the e-waste Disposal Company. After finalizing the deal between the customer and the disposal companies, the e-waste disposal company will start a conversation regarding product's RFID. The conversation will relate with the disposal action plan as well as the refund amount decided by the customer with the RFID. For example, the RFID will be decided only after inspecting the product condition, only company will decide either to refurbish or reuse the products or recycle the products. The e-waste disposal company will then be accountable of directing this information to the cyber infrastructure. The planned system will increase the proper management of e-waste including collection and enhance material recovery for recycling and also reduce the environmental impacts related with abstraction of natural resources. The proposed system will encourage reuse of equipment and parts also reduce the environmental burdens associated with the production of new products. This method of e-Market for Returned Deposit, could also resolve the exportation of e-waste to other countries. Therefore, proper guidelines that contain perfect responsibilities for e-waste disposal companies should be accepted, along with total accountability of the e-waste share they acquire. The said accountability includes transportation, treatment and disposal of recycling-reuse waste inside and outside the United States. The mentioned proposal is already being executed by associations like "World Reuse, Repair and Recycling Association" that are applying their members a trade that meets the association's environmental standard for foreign reuse, repair and recycling [24].The proposed plan will enhance the market driven by economic incentives for product recycling or reuse. The e-Market for Returned Deposit system offers the most sustainable approach for e-waste management in the U.S [6].

C. Proposed Adhaar Card Based Tracking System in India:

During the course of the study, it has been observed that rudimentary management practices are prevalent with low level of public awareness. People are perplexed regarding the disposal of their obsolete electronics. Most of the obsolete electronics are stored in the warehouses and store-rooms of several households, educational institutes, IT companies, businesses and other public and private sector units.

To ensure the proper channelization and tracking of e-waste from producer to recycler, there has to be an independent Government body that can monitor the transaction of electronic products from its origin to end of life. For implementing the same following are the proposed methods/mechanism at different levels in distribution system, to trace the EEE.

Producers have to maintain the records of take back dates (on the basis of life span of the product) and follow up with respective distributors/dealers/retailers for the same. At the time of purchase of new product, the retailer will update the consumer about the take back price of the said product on the date of take back. The price should be as per the age of the product on the take back date.

1) *Example:* Suppose a consumer buys a product on 1st Jan'17 for an amount INR1, 00,000, and the take back date is 1 Jan. 2018 so the take back price shall be Rs. 60,000. Table 1 shows the year wise take back price, if the consumer agrees to keep the product even after the take back date.

Table 1
Year Wise: Take Back Price

Date of take back	Take back price	Depreciation on selling price	Remarks
Before 1st Jan'18	60,000	40%	
Before 1st Jan'19	40,000	60%	
Before 1st Jan'20	25,000	75%	Optimum life span
Before 1st Jan'21	10,000	90%	
After 1st Jan'21	4,000	96%	Scrap

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Although the list suggests the year wise price, it is recommended that the retailer/manufacturer defines the optimum life span for each product and its depreciation on selling price. This will be helpful in reducing the quick replacement of electronic products and hence reduction in e-waste. The scrap value of the product should also be mentioned in the list.

2) *Consumer:* Every electronic product purchased by a consumer has to be linked to his/her Adhaar/PAN ID, to keep the history of purchase and return of electronic products all over India. If the consumer is buying an electronic product which he or she already owns than some extra tax/money should be charged to sensitize the people about using dumping and wastage of products. For e.g., now a days people carries 2-3 mobile handset and dispose it of as routine waste which is not at all advisable, same is the case observed in many other electronic gadgets.
3) *Retailers:* Retailers have to maintain the record of consumer data base (Adhhar/PAN linked purchases) and the data will be accessible to the Government via a specially designed software/portal.
4) *Collection Centre*: The Government has to provide a unique ID to all the recyclers that collect e-waste from collection centres. This unique ID will provide authenticity of transactions in the system and also check inclusion of informal sector. The appointed government bodies have to monitor and audit the compliance of each mechanism at all levels. There should be incentives for compliance and penalty/fine for non-compliance.

VI. CONCLUSIONS

Disposal of e-waste or improper management of e-waste has emerged as a problem in Asian countries especially in India. There is a continuous increase in the manufacturing of electronic products along with advancement in technology and innovation, which is subsequently increasing the generation of e-waste. It is necessary to make people aware about the consequences of e-waste in near future and its harmful impact on environmental and human health. The e-waste tracking system of electrical and electronic products will enable effective monitoring to manage the e-waste at the end of life. Approaches like take back price quotes will encourage the consumers to return their e-waste to the producers. The different stakeholders involved in the production, manufacturing, consuming, buying and selling need to be sensitized to control the generation of e-waste and improper disposal. Association of the electronic products to the Adhhar card/ PAN card will help the government as well as manufacturers to trace the e-waste and assure that at the end of life, electronic waste has been properly recycled to recover the precious metals. The disposal habit of consumers before the end of life of products can be checked through the tracking system. The availability of information like date on websites/records will also hold manufacturers responsible and accountable, if they are not taking proper actions or asking the consumers to return their goods after their life spans ends or hand it over to authorize recyclers before buying the new electronic products. The aim of the paper is to propose a sustainable solution to manage the e-waste.

VII. ACKNOWLEDGMENT

The authors greatly acknowledge Amity University for undertaking this research.

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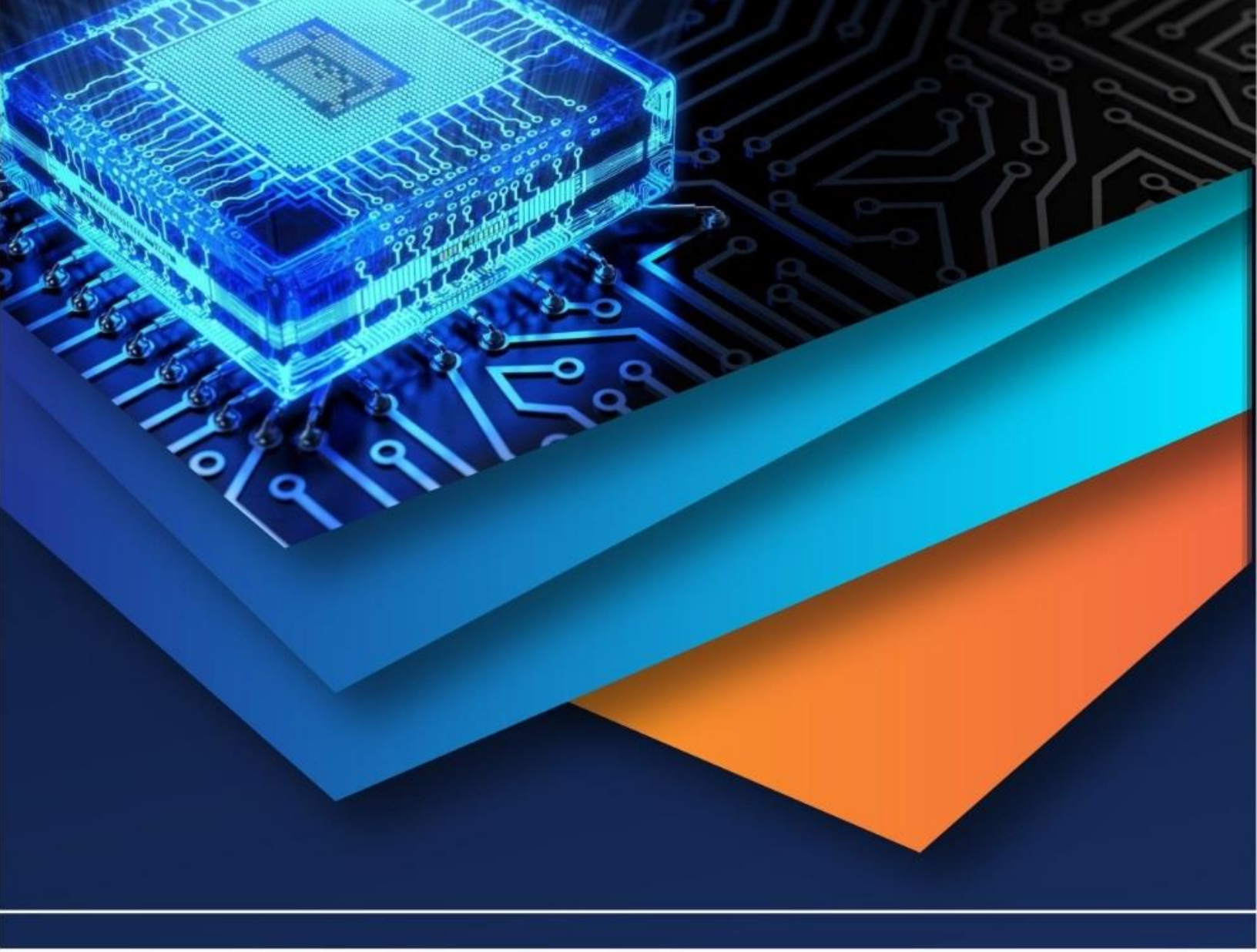

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