E-Waste Management – Why to go for it?

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***Abstract*—In today's world of rapid technological advances, what is the fate of old and discarded electronic equipments is worth a thought. As technology is renewed, a major challenge is the disposition process of obsolete equipment often termed as the "Equipment End life Crisis".**

This research paper highlights why e-waste is so harmful and the statistics of waste generation figures. It emphasizes on the role of the global regulatory bodies by seeing the existing regulations in the field of e-waste management. The reason why some of the companies are doing E-waste management? What is the business value to a company doing e-waste management is studied. What is the potential that this sector offers to the recycling companies? It also highlights some of the class action suits around e-waste globally and different processes that organizations can follow to deal with the problem of E-waste. Global reporting standards for E-waste management are also recommended in this paper for the companies.

Data for research for this paper was primarily collected from reliable secondary sources. Reports and documents analyzed were all genuine sources and these are clearly mentioned in the references section.

***Keywords*—E-waste, Recycling, WEEE, RoHS, EPR, ORDEE**

I. INTRODUCTION

E-waste guide, an online initiative of the Indo-German-Swiss partnership for e-waste management, describes electronic waste as "a term used to describe old, end-of-life electronic appliances such as laptops, TVs, DVD players, mobile phones, mp3 players etc. which have been disposed of by their original user " [1]. Any obsolete appliance that uses electricity and is deemed worthless can be considered as E-waste.

Advances in the field of technology have lead to the availability of a number of easy to use and affordable home appliances resulting in widespread use in households. The challenge arises once this becomes old and has to be disposed.

II. PROBLEM

The presence of a large number of harmful chemicals, heavy metals, toxins and hazardous substances in the E-waste, make it a potential threat for the environment and human health. Two major challenges faced here are reducing the use of toxic materials in the manufacturing processes of these goods and promoting sound disposal of e-waste.

For example, Table I illustrates the highly toxic elements present in an average computer weighing approximately 31.5 Kg [2]. It mentions the part of the computer made of that element, its weight in kilograms and the harmful effects that exposure to each of these elements has on living beings. A total of 9.24 kg of the entire weight of the computer is comprised of these harmful substances. The plastics and lead are the major toxic constituents in the manufacturing of a computer. They are present in the outer assembly of monitor, CPU and cables [3].

III. MARKET FOR ELECTRONIC / ELECTRICAL GOODS – E-WASTE GENERATION FIGURES

A. Indian Scene

The electronic and electrical goods are largely classified under three major heads:

- "White goods" comprising household appliances like air conditioners, dishwashers, refrigerators and washing machines.
- "Brown goods" comprising Televisions, Camcorders, Cameras etc.
- "Grey goods" like Computers, Printers, Fax machines, Scanners, etc.

The categorization is on the basis of the amount of toxic elements present in each category. The white and brown goods are comparatively less toxic compared to the grey goods. This makes it more complex to recycle the grey goods. To add to this complexity, in the recent time, there has been a major growth in the grey goods market. This is highlighted in the annual report 2010-11 of MAIT (Manufacturer's Association for Information Technology) Fig. 1 [4].

The personal computer sales have seen a major jump in last few years- from around 3.8 million in 2004-05 to 9.7 million units in 2010-11. This amounts to CAGR of 16.8% from 2004 to 2011. Growth over 2010-11 has been 21%.Due to rapid innovations in technology, the grey goods have a high rate of obsolescence, due to the lack of technological ability to support up-gradation. Also, strategically the products are designed to be launched in several versions. Once a new version comes to market, the

old one is rendered obsolete. This in turn leads to increase in E-waste.

Table I: Effects of E-Waste constituent on health [3].

Part of the computer in which harmful element is present	Element	Elements by weight in an average computer of 31.5 kg	Harmful effects on living beings
Outer shell of the computers and Cabling	Plastics	7.24kg	Harm on the development of children's brains and reproductive organs
Computer Monitor, Cathode Ray Tube (CRT) and Circuit Boards	Lead	1.98kg	Causes vomiting, diarrhea, convulsions, coma or even death
Circuit Boards include batteries made of mercury, as well as mercury switches.	Mercury	.693gm	Disruption of the nervous system, Damage to brain functions, DNA damage and chromosomal damage, and Allergic reactions
Circuit Boards, LCD displays and Computer Chips	Arsenic	.4095gm	Irritation of the digestion system. Carcinogen, cited as a cause in everything from skin cancer to liver cancer
SMD, Chip Resistors, Infrared Detectors and Semiconductors	Cadmium	2.961gm	Highly toxic, Collects in the human body, in particular in kidneys
Keyboards, and Computer Mouse	Chromium	1.98gm	Effects on the respiratory system. Caused lung cancer in animals if inhaled. Carcinogenic to humans
CRT's to protect users from radiation	Barium	9.92gm	Cause paralysis and in some cases even death. Increased blood pressures, heart rhythm changes, changes in nerve reflexes
Circuit Boards and Connectors	Beryllium	4.94gm	Carcinogen causes cancer and changes of DNA within animals
		Total = 9.24 kg	

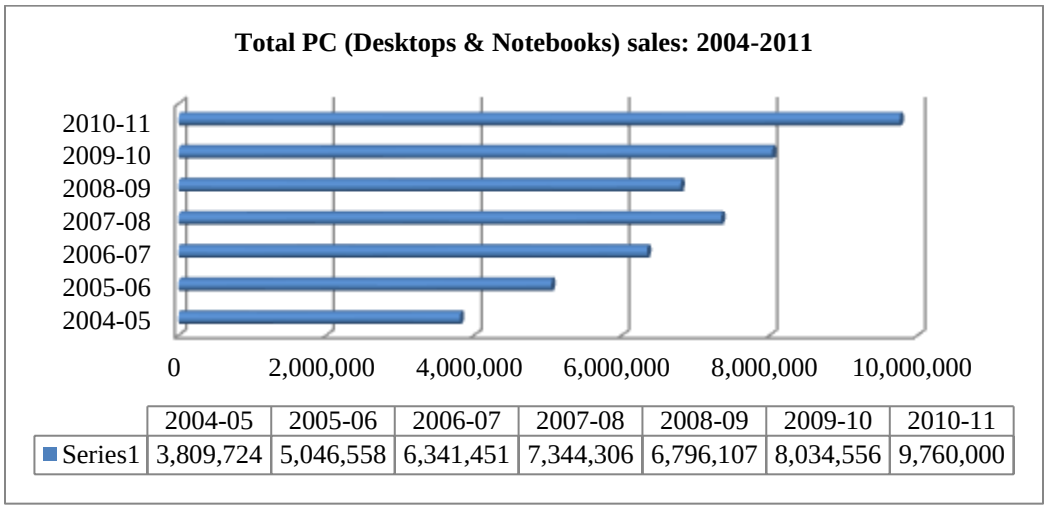

Figure 1: Total PC sales in India: 2004-2011 [4].

India is a growing economy with increasing consumption rates. Fig.2 shows that a waste generation figure of 3.93 lakh tonnes in 2008, has risen to 4.86 lakh tonnes in 2011. This amounts to a CAGR of 7.3%. This includes computers, mobile phone and television only. Also, it is estimated to grow at a CAGR of 10-15% in the coming years. The majority of E-waste generated in India comes from government institutions and business houses using electronic

and electrical equipments, accounting for around 70% of the total waste. The contribution of individual households in comparison is relatively small [5].

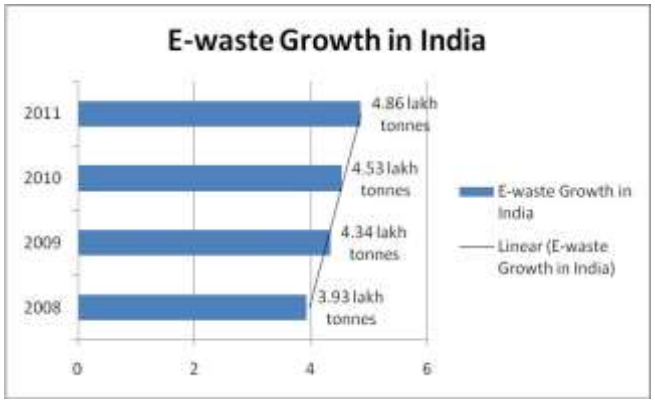

Figure 2: E-waste growth projections in India [5]

B. Global scenario

The global E-waste market is forecasted to reach 53 million tons by 2012 from 42 million tons in 2008; thus growing at a CAGR of 6 percent. As per the analysis by the organization TechNavio, the global E-waste market will grow at a CAGR of 9.2% over 2010-2014 [6].

The developing countries are filled with huge piles of hazardous E-waste mountains with serious consequences for the environment and public health. Strict action needs to be stepped up to check the state of these countries. The sales of electronic products in countries like China and India and across continents such as Africa and Latin America are set to rise sharply in the next 10 years.

Despite having banned e-waste imports, China remains a major e-waste dumping ground for developed countries. In addition China produces about 2.3 million tons (2010 estimate) domestically, second after the United States with about 3 million tones.

This e-waste generated does not have a proper method to be handled. Most of it is destroyed by backyard recyclers to recover valuable metals like gold. This releases fumes causing toxic pollution and metal recovery is very low, since these recyclers are not as equipped as industrial setups [7].

IV. THE STAKEHOLDERS

The stakeholders associated in the E-waste Management system are:

A. ***Manufacturers***

B. ***Users***

- ***Individuals***
- ***Small Business***
- ***Large institutions, government organization and corporations***

C. ***Recyclers***

D. ***Legislators and Policy makers***

V. SOLUTION FOR E-WASTE MANAGEMENT

A. Basel Action Network

In the early 1980's when it came to light that due to a heavy cost of disposal of hazardous waste, the developed countries were shipping their hazardous waste to developing countries in Asia and Easter Europe, the Basel convention was drafted and came into effect.

Often known as BAN (Basel Action Network), it states that no hazardous wastecan be exported to poor countries, and that the developed nations should adopt the "Basel Convention on the Control of Trans-boundary Movements of Hazardous Waste & their Disposal" and BAN was adopted in March 1989. It has been adopted by 172 parties and came to force in 1992[8].

B. International Proceedings

There have been various international proceedings to deal with the problem of E-waste in developed nations.

The European Union has enacted two Directives, one detailing producer's responsibility and the other on putting restriction on the use of hazardous substances in the manufacturing of products [9].

1) Product recycling with Producer Responsibility (Waste Electrical and Electronic Equipment, WEEE)

The producer himself at the first stage guarantees the financing of the management of E-waste arising after the end of life of the product. His responsibilities include appropriate labeling, educating the end users on waste treatment facilities, enabling the infrastructure for collection of waste, maintaining the sales and recovery data, and financing WEEE costs.

- Switzerland introduced the first legal regulation on WEEE, an Ordinance on the return, take back and disposal of Electrical and Electronic equipment in 1994 (ORDEE). This came into force on 1 July 1998. Under this, the retailers and manufacturers have to take back their obsolete stock at no cost. On the other end, the customers cannot discard obsolete items as household waste. Collection and disposal, financed on a private-sector basis, is managed by the Swiss Foundation for the Disposal of Wastes (S.EN.S) and the Swiss Association for Information, Communication and Organizational Technology (SWICO). The rationale behind this law is that, a prepaid disposal charge is already included in the selling price of the appliance.

2) ***Restriction on the use of Hazardous Substances, RoHS).***

The purpose of RoHS directive is to restrict the use of hazardous substances in electrical and electronic equipment and to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment.

- German Electrical and Electronic Equipment Act - ElektroG Act - came into force in March 2005. This handles the sale, return and sound disposal of e-waste. It aims at reducing waste volumes by promoting reuse, collection, recovery and recycling the obsolete equipment. Also, it caters to RoHS by imposing a ban on the use of certain hazardous substances in the manufacture of new electrical and electronic equipment. The producers thus look at the entire life cycle of the product.

The US introduced a bill known as the Responsible Electronics Recycling Act which restricts the export of restricted electronic goods from US to developing economies [10].

C. Legislative Aspects of E-waste Management

A few legislative aspects worldwide are highlighted below.

1) ***India***

The Hazardous Waste (Management & Handling) Rules, 1989*:* This deals with handling and disposal of toxic and hazardous wastes generated from electronic component manufacturing [11]. It defines the hazardous waste generated through various industrial and production process and specifies norms for their concentrations. Also, it lists waste considered hazardous with regard to imports and exports.

2) ***Japan***

There are two laws to deal with E-waste [12].

- LPUR (Law for the promotion of effective utilization of resources) deals with recycling of goods and reducing e-waste generation. It is based on voluntary efforts by the manufacturers.
- LRHA (Law for the recycling of specified kind of home appliances) deals with recycling of home appliances and imposes mandatory responsibility on manufacturers.

3) ***USA – E-waste Law***

The manufacturers are required to offer free programs for customers dropping off old electronics for responsible recycling or reuse. Each company recycles or reuses a certain amount of e-waste by weight each year according to their market share in the state, which is based on a three-year average of their sales [13].

D. Cases of Punishments against violation of laws

There are some cases in and around the world where companies had faced some punishments for violating the laws. We have taken some examples:-

- A retail chain Boots in Ireland, has been caught out by WEEE regulations in Ireland. Boots was legally obliged to inform customers that the price paid for electronic equipment included a contribution towards recycling electrical appliances at the end of use. The company failed to carry out this obligation within in-store advertising as well as advertising placed with the Irish Times. A district court in Wexford imposed a small fine on Boots – the equivalent of £820 – as well as costs of £4,691 for the Environmental Protection Agency on 23rd Jan 2006 [14].
- Aston and Fincher Ltd (Hairdressing supplies wholesaler) Birmingham (UK) Company was fined £650 ($1000) by the Environment Agency under the Producer Responsibility legislation. As per the law, the company, who handles packaging as manufacturers, pack fillers, sellers, importers or leasing companies should be registered each year and provide evidence that they have recycled packaging. The Environment Agency investigations found that Aston and Fincher Ltd had committed offences in each year from 2001 to 2008 [15].
- Plymouth City Council (UK) has been fined £8,000 for allowing unauthorised firms to remove and sell unwanted computers from its waste plants. They did not check if they were bona-fide recyclers. The Environment Agency took the council to court where it was also told to pay £3,742 in costs [16].

All the above examples tell us the role of a producer's responsibility to comply with the legal directives.These regulations do not set out to criminalize companies who don't comply; they are about making all producers responsible for their impact on the environment, and helping them to reduce it wherever possible. Businesses have a responsibility for what happens to their waste and should not be ignorant in this regard.

VI. PROCESSES FOLLOWED BY ORGANIZATIONS FOR E-WASTE MANAGEMENT

A. 'Precautionary Principle' and 'Polluter Pays'-

It aims at subsequent phase out of toxic and harmful elements from the products, use of environment friendly materials and methods in their manufacturing and finally most efficient methods of recycling the waste. The producer must take care of the complete life cycle of the product so that it causes the least burden to the environment.

B. Extended Producers Responsibility (EPR) or Individual Producers Responsibility (IPR) –

Producers should look at both the downstream and upstream technology of product life. End-of-life costs to be fed back to the individual producer. This would promote sound environment management technology and also aims at

better raw material, cleaner production technology, take back logistics and designing for longevity.

C. *Using cleaner technologies in Manufacturing Processes:*

At the product design stage itself, the recycling potential must be considered. Environment friendly technology should be adopted in the manufacturing process by incorporating principles of Design for Environment (DfE). Modular, easily recyclable parts can be used in product design.

D. *Cleaner Technologies at Disposal Stage:*

Companies should involve in taking utmost care to use environment friendly technology at disposal stage. Companies like Intel, Nokia who buy back the used material and send it for authorized recycling.

E. *Reverse Supply Chain:*

There should be an established system of reverse supply chain, enabling formal recycling facilities to operate.

Organizations must ensure the collection of old and discarded products of concern and their transport to appropriate treatment (e.g. recycling facilities). Waste collectors would give money to owners of obsolete items, the amount for which can be negotiated between the two of them. This can be based on estimated potential revenue from recycling or reuse. For reverse supply chain to function, EPR can ensure that material is available for recycling via the producer's vast network. [17].

VII. REPORTING STANDARDS FOR E-WASTE

At present some of the companies are reporting the E-waste collected, recycled or disposed. For instance, HCL publishes the quantity of waste it has successfully collected and recycled on its internet portal. It reports E-waste in terms of the percentage of the waste recycled. (This percentage of waste recycled has been increasing from 2005 to 2011) [18]. While Wipro maintains an online e-waste disposal chart that indicates the amount of e-waste disposed by Wipro each month [19]. So we see that at present there is a need for global reporting standards for E-waste. This will facilitate standardization in e-waste management process and help compare the statistics of different companies in the same industry. As shown in Fig.3, we propose that the Global reporting standard that would be, for an organization, must report the toxic contents at each stage as highlighted.

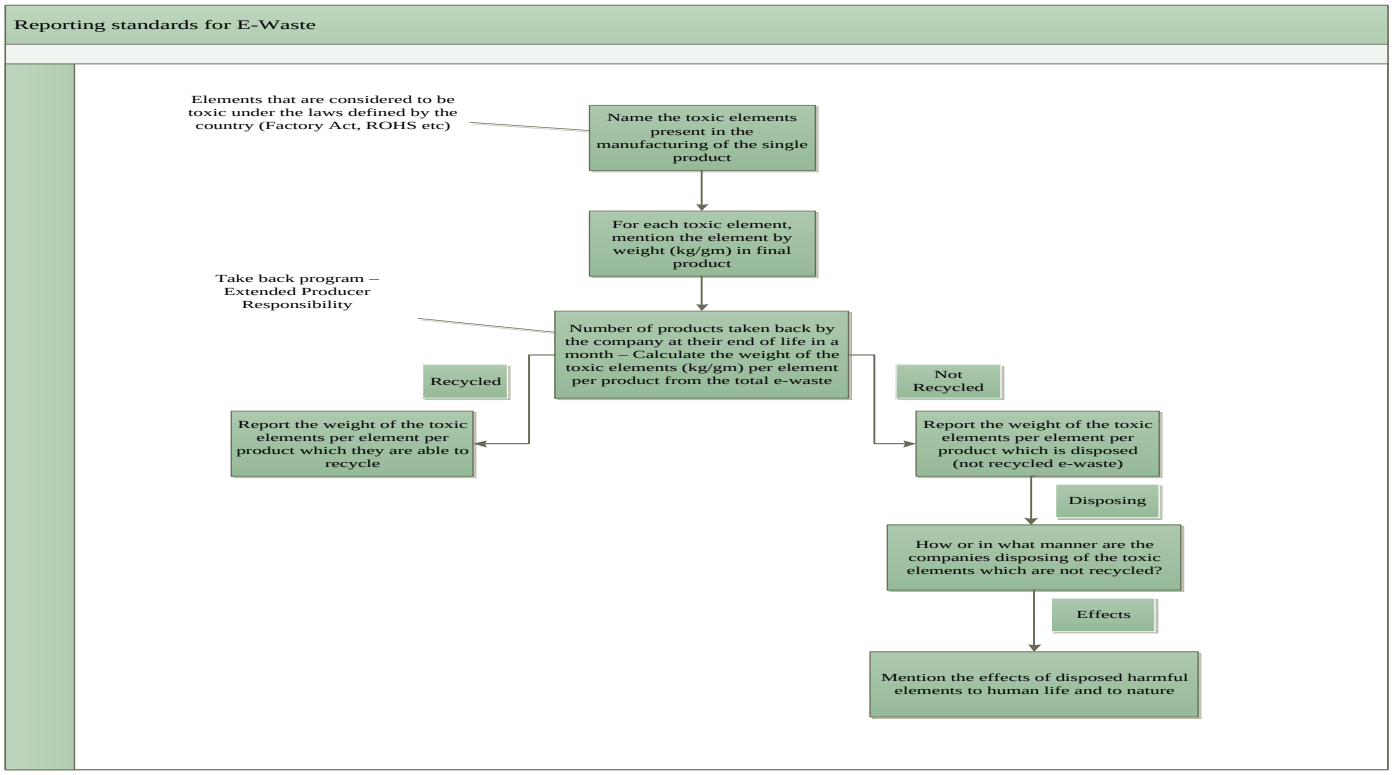

Figure 3: Reporting standards for E-Waste

VIII. SCOPE FOR E-WASTE MANAGEMENT COMPANIES

Looking at the amount of E-waste produced globally and the number of existing recyclers, there clearly is a scope for a large number of firms to fit in. Several job opportunities are generated which may be in collecting, processing, and recycling or disposing the waste. This sector would be free from recession as well. People would still

need to communicate and use the electronic/electrical equipments. There in, lies a huge scope for new recycling companies to thrive and tap this market.

According to Manufacturers' Association for Information Technology (MAIT), the current Indian e-waste management companies are of two types - Formalized and In-formalized, with the In-formalized recyclers constituting the majority of the two. Some of the major e-waste management and recycling companies in the formal sector are as follows:

A. ***e-Parisara:***

Located on the outskirts of Bangalore, India. This company has tie ups with corporations like ABB, TATA Elxsi, IBM etc. The company can process close to 300 tons of e-waste per year.

B. ***Infotrek Syscom:***

Located in Navi Mumbai, this company is into recycling, repairing, refurbishing etc. for corporations. Capacity is not known.

C. ***Trishyiraya Recycling:***

Located in Chennai, India with offices in other parts of India as well. This company is primarily into recycling of waste products. Trishyiraya has the capacity to process about 400 tons per year.

Other formal recyclers that exist operate on a much smaller scale confined to their specific locations. This sector is not much developed in India, which can be attributed to a lack of awareness, lack of regulations, neglect towards the environment etc. On the contrary, the informal recyclers exist in abundance, predominantly in and around the capital city of Delhi [20].

IX. OPPORTUNITIES

As we saw, at present, the unorganized or the informal sector has a huge hold in the recycling area. Thus, there lies a good opportunity for the companies wishing to enter as formal recyclers. Since the collection, processing and disposal of e-waste by companies is complex and would also involve a good number of resources, majority of the companies would like to outsource this to specialists in this area. This way they can focus on their business activities and the companies in the e-waste processing can develop their expertise in asset recovery and recycling. Asset recovery would reduce the waste disposal costs and companies like Intel, Nokia etc can then work to optimize the utilization of these assets.

X. CHALLENGES

A few major challenges dawn upon the e-waste management industry. Firstly, there is a lack of awareness among individuals and organizations with respect to the harmful effects of E-waste and the immediate attention it demands.

A major challenge is getting the households and corporations to understand the true impact of the inaction and also to get them to take actions to correct this in the future. To change the attitude of companies, government must come up with incentives to companies which adopt e-waste management practices. Subsidy can be provided to the e-waste recycling business such that large e-waste recycling plants can be established. The Government should encourage awareness campaigns and enforce stricter laws and regulations.

XI. CONCLUSION

The demand for electronic and electrical goods will increase and as a result so would the e-waste arising out of discarding the old ones. Thus, E-waste management demands prime attention. The adoption of policies and regulations in place is completely voluntary by the companies. The companies must incorporate recycling in business planning to adopt eco-friendly practices. The producer's responsibility will increase to take care of the end of life cycle of the product. The processes will become more streamlined with the presence of more number of formal recyclers. The government must enforce stricter laws and increase awareness in this respect. Also, as suggested by us, a global reporting standard would go a long way in helping the companies compare their practices vis-a-vis their competitors. There would be a record of the e-waste generated and recycled, which could be used to check the practices.

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