Case Study - Present Scenario of E-Waste Management in India

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Abstract— "E-waste" is a popular, informal name for electronic products nearing the end of their "useful life. "E-wastes are considered dangerous, as certain components of some electronic products contain materials that are hazardous, depending on their condition and density. The hazardous content of these materials pose a threat to human health and environment. Discarded computers, televisions. VCRs. stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater. Many of these products can be reused, refurbished, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem. This paper highlights the hazards of e-wastes, the need for its appropriate management and options that can be implemented.

Key words: Hazardous Components of E-Waste, E-Waste Management

I. INTRODUCTION

It is a hard fact that with the voluminous increase in use of ICT devices to bridge the digital divide, there is also an alarming growth of e-waste worldwide. E-waste is defined as "waste electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded" whereas electrical and electronic equipment has been defined as 'equipment which is dependent on electrical currents or electro-magnetic fields to be fully functional'. There is a need for e-waste management as e-waste components may cause severe health risks and environmental damage, when crude, unscientific methods are applied for recovery of useful components. There is a need to encourage recycling of all useful and valuable material from e-wastes to preserve the natural resources. It is an emerging problem as well as a business opportunity of increasing significance, given the volumes of e-waste being generated and the content of both toxic and valuable materials in them. The fraction including iron, copper, aluminium, gold and other metals in e-waste is over 60%, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70% (Widmer et al., 2005). Most of the developing countries are suffering with the rapidly growing problems of e-waste and have to have sound e-waste management systems for end of life ICT products to avoid the threat on environment and mankind.

Fig. 1: E-Waste

A. *Effects on Environment and Health*

E-waste is highly complex to handle because of its composition. It is made up of multiple components some of which contain toxic substances that have an adverse impact on human health and environment if not handled properly that is if improper recycling and disposal methods are deployed. So there is a need for appropriate technology for handling and disposal of these chemicals. Basel Convention characterizes e-waste as hazardous when they contain and are contaminated with mercury, lead, cadmium, polychlorinated biphenyl etc. Wastes containing insulation or metal cables coated with plastics contaminated with or containing lead, coal tar, cadmium, Polychlorinated Biphenyl (PCB) etc. Also precious metal ash from printed circuit boards, glass waste from cathode-ray tubes, LCD screens and other activated glasses are classified as hazardous wastes.

Effects of some of the prime hazardous components in of e- waste are mentioned below:

S. No.	Hazardous Components.	Effect of Hazardous Components of E-Waste
1.	Lead (PB)	– May affect kidneys, reproductive systems, and nervous connections. – May cause blood and brain disorders, sometimes may be fatal.
2.	Arsenic	– Can affect skin and can decrease nerve conduction velocity. – Chronic exposure to arsenic may cause lung cancer and – Sometimes be fatal.
3.	Barium	– Can affect heart muscle.
4.	Chromium	– Can damage liver, kidneys and may cause asthmatic bronchitis and lung cancer
5.	Beryllium	– May cause lung diseases.
6.	Mercury	– Affects the central nervous system, kidneys and immune system, – It impairs foetus growth. May cause brain or liver damage
7.	Cadmium	– May cause severe pain in the joints and spine. It affects the – Kidneys and softens bones.

8.	Polyvinyl Chloride (PVC)	– PVC contains up to 56% chlorine and when burnt, produces Hydrogen chloride gas which in turn produces hydrochloric acid that is dangerous to respiratory system.
9.	Chlorofluorocarbon (CFC)	– May affect the ozone layer. It may cause skin cancer in human and genetic damage in organisms.
10.	Polychlorinated Biphenyl (PCB)	– May cause cancer in animals, can affect the immune system, Reproductive system, nervous system, endocrine system. PCBs persistently contaminate in the environment and cause severe Damage.

Table 1: Effects of some of the prime hazardous components in of E-Waste

II. Management of e-wastes

It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. These electronic junks lie unattended in houses, offices, warehouses etc. and normally mixed with household wastes, which are finally disposed off at landfills. This necessitates implementable management measures. In industries management of e-waste should begin at the point of generation. This can be done by waste minimization techniques

And by sustainable product design. Waste minimization in industries involves adopting:

- Inventory management,
- Production-process modification,
- Volume reduction,
- Recovery and reuse.

A. *Inventory Management*

E-waste inventory is important to estimate the quantity of e-waste generated in Thailand. The data required for development of e-waste inventory includes: sales quantity, average weight of appliances, lifetime of appliances, and replacement factor. The first three data were collected from secondary sources. The replacement factor was derived from the growth rate of the market wherein the latter was calculated from the number of sales. Moreover, the future trend of e-waste was estimated, as the number of sales in the future is predictable E-waste inventory is important to estimate the quantity of e-waste generated in Thailand. The data required for development of e-waste inventory includes: sales quantity average weight of appliances, lifetime of appliances, and replacement factor. The first three data were collected from secondary sources. The replacement factor was derived from the growth rate of the market wherein the latter was calculated from the number of sales. Moreover, the future trend of e-waste was estimated, as the number of sales in the future is predictable E-waste inventory is important to estimate the quantity of e-waste generated in Thailand. The data required for development of e waste inventory includes: sales quantity, average weight of appliances, lifetime of appliances, and replacement factor. The first three data were collected from secondary sources. The replacement factor was derived from the growth rate of the market wherein the latter was calculated from the number of sales. Moreover, the future trend of e-waste was estimated, as the number of sales in the future is predictable Inventory management is a discipline primarily about specifying the shape and placement of stocked goods. It is required at different locations within a facility or within many locations of a supply network to precede the regular and planned course of production and stock of materials. The scope of inventory management concerns the balance between replenishment lead time, carrying costs of inventory, asset management, inventory forecasting, inventory valuation, inventory visibility, future inventory price forecasting, physical inventory, available physical space, quality management, replenishment, returns and defective goods, and demand forecasting. Balancing these competing requirements leads to optimal inventory levels, which is an ongoing process as the business needs shift and react to the wider environment. Another inventory management procedure for waste reduction is to ensure that only the needed quantity of a material is ordered. This will require the establishment of a strict inventory tracking system. Purchase procedures must be implemented which ensure that materials are ordered only on an as-needed basis and that only the amount needed for a specific period of time is ordered.

B. *Production-Process Modification*

Changes can be made in the production process, which will reduce waste generation. This reduction can be accomplished by changing the materials used to make the product or by the more efficient use of input materials in the production process or both. Potential waste - minimization techniques can be broken down into three categories:

- Improved operating and maintenance procedures
- Material change and
- Process-equipment modification. Improvements in the operation and maintenance of process equipment can result in significant waste reduction. This can be accomplished by reviewing current operational procedures or lack of procedures and examination of the production process for ways to improve its efficiency. Instituting standard operation procedures can optimize the use of raw materials in the production process and reduce the potential for materials to be lost through leaks and spills. A strict maintenance program, which stresses

Corrective maintenance can reduce waste generation caused by equipment failure. An employee-training program is a key element of any waste reduction program. Training should include correct operating and handling procedures, proper equipment use, recommended maintenance and inspection schedules, correct process control specifications and proper management of waste materials. Hazardous materials used in either a product formulation or a production process may be replaced with a less hazardous or non-hazardous material. This is a very widely used technique and is applicable to most manufacturing processes. Implementation of this waste reduction technique may require only some minor process adjustments or it may require extensive new process equipment.

For example, a circuit board manufacturer can replace solvent-based product with water-based flux and simultaneously replace solvent-vapor degreaser with detergent parts washer.

C. Volume Reduction

Solid waste management plants in India are equipped with facilities for segregation, repacking, compaction, incineration and embedment of radiation sources. Compaction provides economic benefit in terms of lower volumes for disposal of non-incinerable waste. The present emphasis is on design of super compactors (> 1000 te) with a view to achieve higher volume reduction factors and minimize exposure to personnel. A hydraulic compactor of 200 tone capacity has been developed and deployed along with the requisite material handling and PLC-based control system. The waste is compacted along with the metallic drum and reduction in volume of 4-5 times is achieved. The final pelletized product is achieved employing three-stage compaction. This ensures safe and control release of contaminated entrapped air & water. Pelletisation of filters and other waste have not only resulted in the saving of disposal modules, but also major reduction of release of dust associated with otherwise uncompacted filter. On an average 1500 drums and 1200 filters are compacted annually Based on the operational experience of this compactor, a super compactor of 2000 ton capacity is being engineered addressing compaction of highly irradiated components like zircaloy hulls, coolant tubes, glove boxes and other solid wastes (metallic) generated during decommissioning of various nuclear facilities.

D. Recovery and Reuse

This technique could eliminate waste disposal costs, reduce raw material costs and provide income from a salable waste. Waste can be recovered on-site, or at an off-site recovery facility, or through inter industry exchange. A number of physical and chemical techniques are available to reclaim a waste material such as reverse osmosis, electrolysis, Condensation, electrolytic recovery, filtration, centrifugation etc. For example, a printed-circuit board manufacturer can use electrolytic recovery to reclaim metals from copper and tin-lead plating bath. However recycling of hazardous products has little environmental benefit- it simply moves the hazards into secondary products that eventually have to be disposed of. Unless the goal is to redesign the product to use non-hazardous materials, such recycling is a false solution.

III. SUSTAINABLE PRODUCT DESIGN

Minimization of hazardous wastes should be at product design stage itself keeping in mind the following factors.

A. Rethink the product design

Efforts should be made to design a product with fewer amounts of hazardous materials. For example, the efforts to reduce material use are reflected in some new computer designs that are flatter, lighter and more integrated. Other companies propose centralized Networks similar to the telephone system.

B. Use of renewable materials and energy

Bio-based plastics are plastics made with plant-based chemicals or plant-produced polymers rather than from petro-chemicals. Bio-based toners, glues and inks are used more frequently. Solar computers also exist but they are currently very expensive.

C. Use of non-renewable materials that are safer

Because many of the materials used are non-renewable, designers could ensure the product is built for re-use, repair and upgradeability. Some computer *manufacturers* such as Dell and Gateway lease out their products thereby ensuring they get them back to further upgrade and lease out again

IV. THE INDIAN SCENARIO

Last few years India has emerged as one major IT hub and the consumer electronic market has grown in an exponential rate. According to Manufacturers Association of Information Technology (MAIT) the Indian PC industry is growing by 25% compound annual growth rate. Study reports that in 2007, 2.2 million computers were made obsolete and 14 million mobile handsets replaced .The e-waste generated was estimated to be 3,32,979 tons out of which 144,000 tons was recyclable and actually e waste recycled was 19,000, tons. The e-waste processed contained 12000 tons of computers and 7000 tons of TV. It was also estimated that around 50,000 tons of e-waste was generated through import besides 3,32,000 tons generated domestically. Developed countries find it profitable to send e-waste for reuse/ recycling to developing nations because of economic disparities e.g. cost of recycling of a computer in US is $ 20 whereas in India it is $2. So the import of e-waste to India has got enough chance to jump high. There are 10 States that contribute to 70 per cent of the total e-waste generated in the country, while 65 cities generate more than 60 per cent of the total e-waste in India

A. Waste Management Strategies

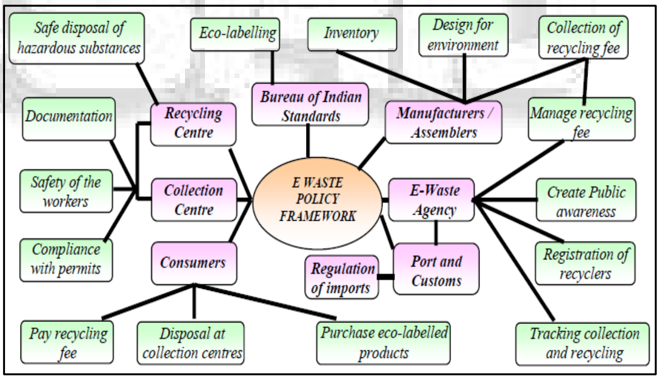

Fig. 2: Elements of e-waste management system for India

The best option for dealing with E wastes is to reduce the volume. Designers should ensure that the product is built for re-use, repair and/or upgradeability. Stress should be laid on use of less toxic, easily recoverable and recyclable materials which can be taken back for refurbishment, remanufacturing, disassembly and reuse. Recycling and reuse of material are the next level of potential options to reduce e-waste (Ramachandra and Saira, 2004). Recovery of metals, plastic, glass and other materials reduces the magnitude of e-waste. These options have a potential to conserve the energy and keep the environment free of toxic material that would otherwise have been released. It is high time the manufactures, consumers, regulators, municipal authorities, state governments, and policy makers take up the matter seriously so that the different critical elements depicted in Figure 1 are addressed in an integrated manner. It is the need of the hour to have an “e waste-policy” and national regulatory frame work for promotion of such activities. An e Waste Policy is best created by those who understand the issues. So it is best for industry to initiate policy formation collectively, but with user involvement. Sustainability of e-waste management systems has to be ensured by improving the effectiveness of collection and recycling systems (e.g., public–private-partnerships in setting up buy back or drop-off centers) and by designing-in additional funding e.g., advance recycling fees.

B. *Responsibility and Role of Industries*

Generators of wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options. All personnel involved in handling e-waste in industries including those at the policy, management, control and operational levels, should be properly qualified and trained. Companies can adopt their own policies while handling e-wastes. Some are given below:

– Use label materials to assist in recycling (particularly plastics).
– Standardize components for easy disassembly.
– Re-evaluate 'cheap products' use, make product cycle 'cheap' and so it has no inherent value that would encourage a recycling infrastructure.
– Create computer components and peripherals of biodegradable materials.
– Utilize technology sharing particularly for manufacturing and de manufacturing.
– Encourage / promote / require green procurement for corporate buyers.
– Look at green packaging options.

Companies can and should adopt waste minimization techniqu.es, which will make a significant reduction in the quantity of e-waste generated and thereby lessening the impact on the environment. It is a "reverse production" system that designs infrastructure to recover and reuse every material contained within e-wastes - metals such as lead, copper, aluminum and gold, and various plastics, glass and wire. Such a "closed loop" manufacturing and recovery system offers a within situation for everyone - less of the Earth will be mined for raw materials, and groundwater will be protected, researchers explain. Manufacturers, distributors, and retailers should undertake the responsibility of recycling/disposal of their own products.

C. *Responsibilities of the Citizen*

Waste prevention is perhaps more preferred to any other waste management option including recycling. Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. But care should be taken while donating such items i.e. the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, non-profit organizations, and lower-income families can afford to use equipment that they otherwise could not afford. E-wastes should never be disposed with garbage and other household wastes. This should be segregated at, the site and sold or donated to various organizations. While buying electronic products opt for those that are made with fewer toxic constituents: use recycled content are energy efficient; are designed for easy upgrading or disassembly. Utilize minimal packaging offer leasing or take back options have been certified by regulatory authorities. Customers should opt for upgrading their computers or other electronic items to the latest versions rather than buying new equipments. NGOs should adopt a participatory approach in management of e-wastes.

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