E-WASTE RECYCLER BY USING PROCESS OF DISTILLATION, SYSTEM OF COLLECTING E-WASTE AND USE OF DROP BOX

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Abstract - In an approach to bridge the digital divide, it is necessary to get an affordable, equitable and quality access to ICT. It is estimated that two third of world's population is still offline so there is a need to provide affordable access to internet for all. For developing countries, it has become a priority area to alleviate poverty by promoting access to ICT.At the same time, tremendous growth in use of ICT devices and services, faster change of technology and frequent innovations in ICT sector, had left the world with a threat of deterioration in environmental conditions and human health as the-waste of electronic and electrical equipment, which contains hazardous components, is still handled in an environmentally unfriendly manner mainly in developing nations. It is huge challenge for the nations to handle e-waste in responsible manner and protect the environment. In this paper an approach is made towards assessing the present situation of e-waste management globally as well as in India, considering the present regulations and guidelines. It is also a fact that major part of recycling of e-waste is being handled by informal sector who have little/no knowledge about the consequences of exposure to hazardous substances. To address the issue of e-waste management in a sustainable method, the concept of EPR (extended producer responsibility) will be helpful if the regulations incorporate monitoring and penalty clauses. The reuse of EEE has greater environmental and social benefits than recycling as it increases the useful life time of the ICT equipment and enables greater resource efficiency and energy efficiency. In developing nations, it can help in uplifting the status of the informal sector with help of education and employment. In addition to the technical, social and organizational aspects of the EEE-waste management system, it is also crucial to consider the economic aspects, if the system has to be made financially viable and sustainable along with being socially acceptable.

Keywords - E-waste, processes of distillation, system of collecting, use of drop box.

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. 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. The rapid growth of ICT, frequent innovations and technological changes are resulting in shorter life span of ICT equipment. Moreover in developing countries the quantity of imported disused Electrical and Electronic equipment (EEE) is uncontrolled .So the volume of e-waste has also increased drastically in developing and developed nations. At the same time, it is encouraging that every nation, along with going for the development in the ICT sector, is also working for 'going green' by taking care of issues like efficient use of natural resources, minimization of e-waste, sustainable recycling of e-waste and development of products with minimum use of hazardous substances.

Electrical and electronic equipment t (EEE) contain valuable as well as hazardous materials and if at end of life of EEE, the hazardous materials are not disposed of scientifically it may cause serious damage to the environment and public health. The presence of heavy metals (like Arsenic, Cadmium, Barium, Lead, Lithium, Mercury, Nickel, Zinc Sulphide) and other toxic substances like PCB (Polychlorinated biphenyls) etc. may cause extreme harm, if not disposed of in environment friendly manner. ITU has accepted the fact that the regulations in many developing countries to cover the areas of WEEE (Waste Electrical and Electronic Equipment) are in adequate as they exclude key topics and key stake holders like the informal sector. The collection, recycling, recovery and associated activities of e-waste management by the informal sector having little/no knowledge about techniques, precautions etc., cause more damage to their health and environment. So going in line with the definition of environmental sustainability i.e." the ability to maintain the qualities that are valued in the physical environment by the use of design for environment principles, efficient use of non -renewable resources, efficient and environmentally sound recycling and

use of renewable resources as much as possible", in order to have a sustainable policy to handle e-waste in an environment friendly manner, it is thus extremely important that policy of e-waste disposal and regulatory aspects should be stringent as well as rational.

II. AN ESTIMATE OF E-WASTE

The exponential growth of internet users from 501 million in 2006 to over 1.3 billion at in 2011 in developing countries clearly indicates that the sale of computers and other terminals has grown at a lightning pace. In 2006, 44% of internet users were in developing countries whereas in 2011, 62%, were present in developing countries. Personal computer sales has significantly increased from 2000 to 2010, from about 170 million units sold globally in 2000 to about 370 million units sold in 2010. It is projected that sales in 2014 will reach an estimated 470 million units which is more than double in the last 10 years. In India, it is estimated that approximately 1.42 million PCs are getting obsolete every year. ITU data release of June 2012 indicates that total number of mobile cellular subscriptions reached almost 6 billion by the end of 2011, and in the developing countries, about 80% of the 660 million new mobile cellular subscriptions added in 2011were generated.

Year	Global Computer Sales	U.S. Sales	Global Revenue
2015	238,500,000	71,250,000	$273 Billion
2014	302,000,000	89,500,000	$304 Billion
2011	355,200,000	95,400,000	$329 Billion
2010	346,200,000	93,000,000	$321 Billion
2000	134,700,000	46,000,000	$251 Billion
1975	50,000	40,000	$60 Million
Total Number of Computers Sold All Time			**4,187,000,000**

Purpose and Characteristics	Percent of Computer Sold
Percent of computers sold for business	74 %
Percent of desktop computers sold	81.5 %
Percent of laptop computers sold	16.4 %
Percent of servers sold	2.1 %
Region of Sales	
Percent of computers sold to the U.S.	38.8 %
Percent of computers sold to Europe	25 %
Percent of computers sold to Asia-Pacific	11.7 %
Figures include desktop PCs, mobile PCs, and servers using the Intel x86 processor architecture	

Table no. 1 total numbers electrical and electronic waste sale in world.

The report "Recycling - from E-Waste to Resources" issued at a meeting of the Basel Convention estimated that, by 2020 in China and South Africa, the e-waste from computers would increase between 200 and 400% over 2007 figures and 500% in India. It was also estimated that by 2020 in India the amount of e-waste from mobile phones would be 18 times higher than the 2007 figures and 7 times higher in China. Basel Action Network stated that 50- 80% of e-waste generated in USA is exported to India, China, Pakistan, Taiwan and African countries. UNEP estimates that e-waste is increasing by 40% per year worldwide and e-waste is the fastest-growing type of waste. Between 20to50 million metric tons of e-waste are generated worldwide every year, representing more than 5% of urban solid waste, particularly in

some developing countries where the volume is expected to grow up to 500 percent over the next decade. In India, volume of e-waste is estimated to be 0.8 million tons in 2012. According to the Controller and Auditor General's (CAG) report, over 7.2 MT of industrial hazardous waste, 4 lakh tones of electronic waste, 1.5 MT of plastic waste, 1.7 MT of medical waste, 48 MT of municipal waste are generated in the country annually.

III. EFFECTS OF E-WASTE ON HUMAN HEALTH AND ENVIORMENT

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. are also characterized as hazardous wastes. 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	Arsenic	Can affect skin and can decrease nerve conduction velocity. Chronic exposure to arsenic may cause lung cancer and sometimes be fatal.
2	Lead	May affect kidneys, reproductive systems, nervous connections. May cause blood and brain disorders, sometimes may be fatal.
3	Barium	Can affect heart muscle.
4	Chromium	Candamage 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	BFR (Brominates flame retardants)	Can harm reproductive and immune systems, may cause hormonal disorder.
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 .
11	Polyvinyl Chloride (PVC)	PVC contains upto 56% chlorine and when burnt, produces Hydrogen chloride gas which in turn produces hydrochloric acid that is dangerous to respiratory system.
12	Dioxin	These are highly toxic to animals and can lead to malfunction of foetus, decreased reproduction and growth rates, affect immune system.

Table No 2. Effects of Hazardous Component From E-Waste On Heat

IV. MANAGEMENT OF E-WASTE

There is no unique or ideal model for e-waste management in developing countries, each of which has its own specific environmental, social, technological, economic and cultural conditions. Environmentally sound management of WEEE recognizes three Rs i.e. reduce, reuse and recycle. The aim would be to reduce the generation of e-waste through smart manufacturing and maintenance, reuse till functioning of electronic equipment by someone else and recycle those components that cannot be repaired. A smart e-waste management system for developing countries have to assess the e-waste situation, recognize that e-wastes are a complex mixture of hazardous and non-hazardous substances and materials and need to define the integral e-waste management system taking into consideration the EEE market penetration , life cycle of ICT equipment, financing mechanisms etc.

The main aspects to be taken into account when framing ICT waste management guidelines for developing countries are:

a. Policy and regulations covering import and export of EEE and WEEE in accordance with the rules of each country and with international legislation
b. Defining responsibilities of prime stake holders at the level of government, supply chain, consumers of ICT equipment and entities for disposal of waste
c. Extended producer responsibility (EPR) where the manufacturer's responsibility for its ICT equipment extends throughout the various stages of that equipment's life cycle with internalizing the cost of managing the equipment at end of life
d. Responsible information system to have data on ICT equipment in market, disused EEE management and WEEE management and to have control on the monitoring and future planning
e. Promoting employment and training for the informal sector engaged in recycling and recovery of the materials.

E-waste management comprising of two phases

1. Collection : Drop box
2. E-waste recycler

4.1 E-Waste drop box

E-waste drop box is basically a collection box for e-waste. People can drop e-waste into this drop. Drop box will be fitted at every important place like airports, metro stations, railway station, bus-stops, offices, squares, malls etc. This drop box will be fitted with sensors which will inform to e-waste collection centre after filling it completely reducing the man power for collection and handling. After collection all the e-waste will transfer to recycling system which is next phase. Each drop will be provided with unique ID so that with help of Global Positioning System people will come to about drop box near to their location which will make easy for them to locate and reduce the efforts of finding drop box by other means. Drop box will act as a cell which is primary and important part of e-waste recycling. This drop box will segregate the other waste from e-waste since no special provisions are to collect the e-waste acting as key element in recycling. Since segregation of e-waste from other waste will be done by drop box, reducing cost of separating other waste from e-waste.



Fig No.1 Drop Box

4.2 E-waste Recycler

E-waste recycling is the reuse and reprocessing of electrical and electronic equipment of any type that has been discarded or regarded as obsolete. Some of the common E-wastes include: home appliances such as televisions, air conditioners, electric cookers and heaters, air condoners, fans, DVDs, Radios and microwaves among others; information technology equipments such as computers, mobile phones, laptops, batteries, circuit boards, hard disks, and monitors among others; and other electronic utilities such as leisure, lighting, and sporting equipments etc. Recycling of e-waste is a growing trend and was initiated to protect human and environmental health mainly due to the widespread_environmental pollution impacts of e-waste.

4.3. Common Methods Of E-Waste Management

1. Landfill

A landfill site (also known as a tip, dump, rubbish dump, garbage dump or dumping ground and historically as a midden) is a site for the disposal

of waste materials by burial and the oldest form of waste treatment (although the burial part is modern; historically, refuse was just left in piles or thrown into pits). Historically, landfills have been the most common method of organized waste disposal and remain so in many places around the world. Some landfills are also used for waste management purposes, such as the temporary storage, consolidation and transfer, or processing of waste material (sorting, treatment, or recycling). Unless they are stabilized, these areas may experience severe shaking or soil liquefaction of the ground during a large earthquake.

Operations

Typically, operators of well-run landfills for non-hazardous waste meet predefined specifications by applying techniques

1. confine waste to as small an area as possible
2. compact waste to reduce volume
3. cover waste (usually daily) with layers of soil or other types of material such as woodchips and fine particles

During landfill operations a scale or weighbridge may weigh waste collection vehicles on arrival and personnel may inspect loads for wastes that do not accord with the landfill's waste-acceptance criteria. Afterward, the waste collection vehicles use the existing road network on their way to the tipping face or working front, where they unload their contents. After loads are deposited, compactors or bulldozers can spread and compact the waste on the working face. Before leaving the landfill boundaries, the waste collection vehicles may pass through a wheel-cleaning facility. If necessary, they return to the weighbridge for re-weighing without their load. The weighing process can assemble statistics on the daily incoming waste tonnage, which databases can retain for record keeping. In addition to trucks, some landfills may have equipment to handle railroad containers. The use of "rail-haul" permits landfills to be located at more remote sites, without the problems associated with many truck trips. Typically, in the working face, the compacted waste is covered with soil or alternative materials daily. Alternative waste-cover materials include chipped wood or other "green waste", several sprayed-on foam products, chemically "fixed" bio-solids, and temporary blankets. Blankets can be lifted into place at night and then removed the following day prior to waste placement. The space that is occupied daily by the compacted waste and the cover material is called a daily cell. Waste compaction is critical to extending the life of the landfill. Factors such as waste compressibility, waste-layer thickness and the number of passes of the compactor over the waste affect the waste densities.

Advantages

Landfills are often the most cost-efficient way to dispose of waste, especially in countries like the United States with large open spaces. While resource recovery and incineration both require extensive investments in infrastructure, and material recovery also requires extensive manpower to maintain, landfills have fewer fixed—or ongoing—costs, allowing them to compete favourably. In addition, landfill gas can be upgraded to natural gas—landfill gas utilization—which is a potential revenue stream.[3] Another advantage is having a specific location for disposal that can be monitored, where waste can be processed to remove all recyclable materials before tipping.

Social and environmental impact

Landfills have the potential to cause a number of issues. Infrastructure disruption, such as damage to access roads by heavy vehicles, may occur. Pollution of local roads and water courses from wheels on vehicles when they leave the landfill can be significant and can be mitigated by wheel washing systems. Pollution of the local environment, such as contamination of groundwater or aquifers or soil contamination may occur, as well.

Leachate

Leachate Extensive efforts are made to capture and treat leachate from landfills before it reaches groundwater aquifers, but engineered liners always have a lifespan, though it may be 100 years or more. Eventually, every landfill liner will leak, allowing the leachate to contaminate the groundwater. Installation of composite liners with flexible membrane and soil barrier is enforced by the EPA to ensure that leachate is withheld.

Dangerous Gases

Rotting food and other decaying organic waste allows methane and carbon dioxide to seep out of the ground and up into the air. Methane is a potent greenhouse gas, and can itself be a danger because it is flammable and potentially explosive. In properly managed landfills, gas is collected and utilized. This could range from simple flaring to landfill gas utilization. Carbon dioxide is the most widely produced greenhouse gas. It traps heat in the atmosphere, contributing to climate change.

Infections

Poorly run landfills may become nuisances because of vectors such as rats and flies which can cause infectious diseases. The occurrence of such vectors can be mitigated through the use of daily cover.

Other potential issues include wildlife disruption, dust, odour, noise pollution, and reduced local property values.

Landfill Gas

Gases are produced in landfills due to the anaerobic digestion by microbes. In a properly managed landfill

this gas is collected and used. Its uses range from simple flaring to the landfill gas utilization and generation of electricity. Landfill gas monitoring alerts workers to the presence of a build-up of gases to a harmful level. In some countries, landfill gas recovery is extensive; in the United States, for example, more than 850 landfills have active landfill gas recovery systems.

2. Incineration

Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration and other high-temperature waste treatment systems are described as "thermal treatment". Incineration of waste materials converts the waste into ash, flue gas and heat. The ash is mostly formed by the inorganic constituents of the waste, and may take the form of solid lumps or particulates carried by the flue gas. The flue gases must be cleaned of gaseous and particulate pollutants before they are dispersed into the atmosphere. In some cases, the heat generated by incineration can be used to generate electric power. Incineration with energy recovery is one of several waste-to-energy (WtE) technologies such as gasification, pyrolysis and anaerobic digestion. While incineration and gasification technologies are similar in principle, the energy product from incineration is high-temperature heat whereas combustible gas is often the main energy product from gasification. Incineration and gasification may also be implemented without energy and materials recovery. In several countries, there are still concerns from experts and local communities about the environmental effect of incinerators. In some countries, incinerators built just a few decades ago often did not include a materials separation to remove hazardous, bulky or recyclable materials before combustion. These facilities tended to risk the health of the plant workers and the local environment due to inadequate levels of gas cleaning and combustion process control. Most of these facilities did not generate electricity. Incinerators reduce the solid mass of the original waste by 80–85% and the volume (already compressed somewhat in garbage trucks) by 95–96%, depending on composition and degree of recovery of materials such as metals from the ash for recycling. This means that while incineration does not completely replace landfilling, it significantly reduces the necessary volume for disposal. Garbage trucks often reduce the volume of waste in a built-in compressor before delivery to the incinerator. Alternatively, at landfills, the volume of the uncompressed garbage can be reduced by approximately 70% by using a stationary steel compressor, albeit with a significant energy cost. In many countries, simpler waste compaction is a common practice for compaction at landfills.

Incineration has particularly strong benefits for the treatment of certain waste types in niche areas such as clinical wastes and certain hazardous wastes where pathogens and toxins can be destroyed by high temperatures. Examples include chemical multi-product plants with diverse toxic or very toxic wastewater streams, which cannot be routed to a conventional wastewater treatment plant. Waste combustion is particularly popular in countries such as Japan where land is a scarce resource. Denmark and Sweden have been leaders in using the energy generated from incineration for more than a century, in localised combined heat and power facilities supporting district heating schemes. In 2005, waste incineration produced 4.8% of the electricity consumption and 13.7% of the total domestic heat consumption in Denmark. A number of other European countries rely heavily on incineration for handling municipal waste, in particular Luxembourg, the Netherlands, Germany, and France.

3. Acid Bath

Acid bath involves soaking of the electronic circuits in the powerful sulphuric, hydrochloric or nitric acid solutions that free the metals from the electronic pathways. The recovered metal is used in the manufacturing of other products while the hazardous acid waste finds its ways in the local water sources.

4. Reuse of Electronic Devices

This is the most desirable e-waste recycling process where with slight modifications the mobile phones, computers, laptops, printers can be reused or given as second hand product to the other person. The old electronic equipment can also be donated in the various charity programs and thus helping the persons in need. Moreover, there is a better way also by selling the old mobile phones or laptops to the some recycling and refurbishing companies. Several websites are acting as the middleman between recyclers and electronic users. It is a win-win situation for the users as they not only get rid off the old mobile phones but also get paid after reselling it.

4.4 E-Waste Distillation Technique

The e-waste collected from the drop box will be stored at store house; this place will act as storage unit foe e-waste. After which it will be transfer to e-waste recycler. Working of this recycler is based on distillation. Distillation can be explained by the process of separating the component or substances from a liquid mixture by selective evaporation and condensation. Distillation may result in essentially complete separation (nearly pure components), or it may be a partial separation that increases the concentration of selected components of the mixture. In either case the process exploits differences in the volatility of the mixture's components. In industrial chemistry, distillation is a unit operation of practically universal importance, but it is a physical separation process and not a chemical reaction.

Initially boiler covert all the e-waste into vapours since the temperature in boiler convert all solid e-waste into vapours . After which this e-waste liquid is transfer to distillation tower. Distillation tower is made up of various compartments and to these compartments the outlets are provided for collection. We know all elements have different densities and boiling point; distillation tower will separate all the metals, non metals, gases from the e-waste. These vapours will enter into different compartments depending on their density and boiling point. After entering all the vapour into different compartments the outlets are open and these vapours are made cool by refrigerators and made solid. Thus all e-waste will get converted into different small parts by this recycler. The outputs are

a) At top portion : Hazardous gases
b) At middle portion : precious metals
c) At bottom portion : residue

At end of the process the hazardous gases will escape from top, metals will be collected and other residue from the recycler unit will be further treated by other processes. Precious metals will be sold or use for other purposes.

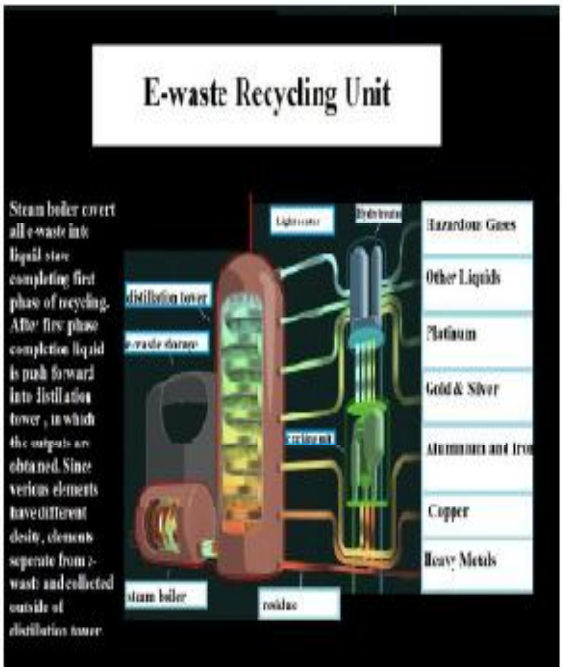


Fig No.2 E-Waste Recycler (Distillation Process)

5.1. Lenovo Initiatives

a. All Lenovo products sold in India comply with RoHS (Restriction of Hazardous Substance) requirements as per India's E-waste management and handling rules 2011.

b. Lenovo has partnered with Sims Recycling Solutions India Pvt Ltd to comply with the new India E-Waste management and Handling Rules in providing drop-off centres and environmentally sound management of end of life equipment Sims India provides 1491 points of presence throughout India.

c. Lenovo India offered a voluntary PC Recycling Service for collecting and recycling end of life Lenovo branded products from private households (consumers) and business customers.

d. During the calendar year 2011, this program collected and recycled 2.12 metric tons of customer returned equipment. Lenovo India also recycled 143 metric tons of Lenovo owned equipment (e.g., employee replaced equipment, channel returns) during calendar year 2010 and 30 metric tons in 2011(Letter on Lenovo's progress of ROHS dated 2.9.2014 by Robert J. Taylor Director of Environmental Affairs, Corporate Quality programs, Safety and Standards, 1009 Think Place, Morrisville, NC 27560).

5.2. Dell Activities

Diverted over 68 million kg (150 million lbs.) of end-of-life electronics globally from landfills in fiscal year 2011, a 16% increase over fiscal 2010.
Since it launched its recycling program globally in 2006, the company has recycled more than 125 million kilograms of electronic equipment and is on track to recycle more than one billion pounds of e-waste by 2014. Piloted a battery recycling program where a customer gets a discount on their new purchase of a li-ion laptop battery upon the return of an identical non-working one.

5.3. NOKIA Activities

Nokia began its e-waste management campaign in 2008 when e-waste disposal was given little attention. Nokia set up drop boxes across the country to take back used phones, chargers and accessories, irrespective of the brand, at Nokia Care Centres or Priority Dealers. It had a number of campaigns involving public. The total quantity of mobile phones and accessories collected from the campaigns since its launch in 2009 is 160 tons. The e-waste collection has grown from three tons in 2009 to 65 tons in 2012
Nokia has sound recycling system and almost 100% of the materials in a phone are recovered and reused. Besides this, a number of innovative campaigns started by Nokia to collect discarded sets. All Nokia phones and accessories sold worldwide are RoHS (Reduction of Hazardous Substances) compliant since 2006. It is claimed that since 2006 Nokia devices, chargers and headsets have been free of PVC (polyvinyl chloride), and since 2009 brominated, chlorinated compounds and antimony trioxide are fading out. Since the beginning of 2010 all new Nokia devices are said to be free of these substances.

5.4. ITC IT E-Waste Policy

IT e-waste is a subset of e-waste and covers IT equipment's like computers, printers and accessories, Network equipment, IT accessories and associated

cables. ITC has a sound policy for handling the IT waste and salient features are mentioned. The lifecycle of all IT assets from acquisition to disposal is to be managed in a manner which conforms to sound environmental norms.

a. Preferential dealing with IT vendors having sound E-Waste management processes
b. Extending the useful life of IT assets to postpone / minimize generation of E-Waste
c. Responsible disposal processes conforming to regulatory requirements and best practices
d. Apart from internal re-use, option to extend use outside ITC through donation to bonafide philanthropic institutions extending the useful life of IT assets.
e. Only such IT assets which are non-operational and cannot be reused for any other alternate purpose should be considered as IT E-waste for disposal.

5.5. Concerns/ Challenges in e -waste management: Following are the some of the major issues that need attention while handling e-waste:

a. The data for information on e-waste is estimation and there is a problem in finding information on imports of e-waste. Most studies have concentrated on devices like mobile, computer and TVs while the domestic appliances also contribute to a considerable proportion of e-waste. There is a need to have credible data covering wide range of products across sectors
b. Waste collection, transportation, processing and recycling is dominated by the informal sector. The sector is well networked and unregulated. There are serious issues regarding leakage of toxins into the environment hampering workers' safety/ health.
c. There is a need for establishment of collection channels for e-waste from the generator to the recycler. Presently as the standards are not followed by the collectors (mainly the informal sector), the environmental, health and safety norms are hampered. The formal sector having large infrastructure and high operational cost finds difficulty in competing with the informal sector.
d. The informal sector needs specific attention to be handled properly considering the socio economic condition so that the solutions for environment friendly management of e-waste are found to be rational for the stake holders
e. There is a lack of fund and capacity in Government for monitoring and enforcement of the regulations
f. Awareness regarding the hazards of e-waste is low because of structural deficiency in implementation of policies, poor literacy and poverty of an important major stake holder (informal sector)
g. The e-waste management system is mostly manual and low tech and the 'take back' by producers is limited to few IT equipment and few formal collection centres. There is lack of effort from producers that results in limited implementation of EPR. In absence of accountability and penalty criteria in the regulation, it is difficult to monitor the EPR activities.

5.6. Towards Sustainability:

ITU-T has provided support and guidance for environmental sustainability for the ICT sector for maintenance and operation of ICT devices and services through number of standards and recommendations. A toolkit has been evolved by ITU-T containing detailed discussions on topics like Sustainable ICT in corporate organizations, Sustainable products, Sustainable buildings, End-of-life management, General specifications and KPIs, Assessment framework for environmental impacts including standards, guidelines and available methodologies. It is well understood that there is a need of having comprehensive strategy for sustainable electronic product design, production and e-waste management.

Presently the sustainability issues at the stages of product design or production mainly incorporated environmental sustainability and so fall short of social, economic and ethical sustainability. To have an e-waste management system which is environment friendly, the following aspects are to be taken into consideration:

a. Remuneration for research and development in the areas of green design/ development and maintenance of ICT product.
b. Incorporation of enforcement clauses in national regulations in a rational way considering the economic conditions of the society
c. Recognition of the importance of the life cycle assessment to have proper estimation on the generation of WEEE
d. Consideration of ethical aspects while addressing the supply chain performances including handling the issues of the informal sector engaged in recycling stages of e-waste management in developing nations
e. Building up the confidence of civil society and consumers in the existing system of e-waste management through mass awareness

With the broad definition of sustainability encompassing economic, social and environmental aspects, it is now necessary mainly for the developing nations, that the international standards/ policies/ guidelines should be adjusted considering the socioeconomic condition of a nation. Being in line with UNDP's millennium development goals, it is an

important criterion for a green society to be socially and ethically sustainable.

CONCLUSIONS

ITU has agreed to the fact that there is no unique or ideal model for e-waste management in developing countries, each of which is characterized by its own specific environmental, social, technological, economic and cultural conditions. With a view to bridge the digital divide, there is exponential growth in the use of Electrical and electronic equipment (EEE) and so there is alarming effect on environment and human health when the ICT wastes are not disposed of scientifically. There is an emergent need to implement the existing policies and guidelines in line with the international standards and practices for a healthy e-waste management system. Government policies should encourage the reuse of EEE aiming to minimize and recycle Waste Electrical and Electronic Equipment (WEEE). The Extended Producer Responsibility (EPR) do need to have clear regulations to mandate the 'take back' activity of companies strictly. There is a clear need to have proper information system through standardized mechanisms. Eco-design can have a positive impact in reducing the rate of WEEE generation, facilitating the management of e- waste and recovery of materials, achieving cost reductions. In Indian context, Ministry of Environment and Forests in the E-waste (Management & Handling- Rules, 2011) has clarified about the Reduction in the use of hazardous substances (RoHS) in the manufacture of electrical and electronic equipment where attempt is made to get ensured that new electrical and electronic equipment does not contain Lead, Mercury, Cadmium, Hexavalent Chromium, poly-brominated biphenyls (PBB) or poly-brominateddiphenyl ethers (PBDE) which is to be achieved within a period of three years from the date of commencement of these rules MoEF is also promoting the 3R Concept (Reduce, Reuse and Recycle) for
Hazardous Waste Management MoEF has also defined the responsibilities of Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) who are acting as monitoring authorities in respect of management of e-waste in India. Briefly the main functions of CPCB are:

a. Coordination with State Pollution Control Boards
b. Preparation of Guidelines for Environmentally Sound Management of e-waste
c. Conduct assessment of e-waste generation and processing
d. Recommend standards and specifications for processing and recycling e-waste
e. Documentation & compilation of data on e-waste
f. Conducting training & awareness program
g. Enforcement of reduction in use of hazardous substances(RoHS)
h. Incentives and certification for green design/products

The collection, storage, transportation, segregation, refurbishment, dismantling recycling and disposal of e-waste is also defined by the guidelines issued by the Central Pollution Control.

The DoT guidelines in the direction "to develop a robust and secure state-of-the-art telecommunication network providing seamless coverage with special focus on rural and remote areas for bridging the digital divide" have also specific regulations for the environmental and health issues arising from the telecom network. The remuneration for adoption of green policy and incentive for use of renewable energy sources can be one practical and sustainable method for managing e-waste in Indian socio cultural environment. By promoting the use of energy efficient equipment and renewable energy technologies, and also adopting measures for reduction of carbon footprint, the concern for e-waste is also addressed in direction of long term sustainability.

RECOMMENDATIONS: A MULTI PROGRAMMER APPROACH IS REQUIRED TO IMPROVE UPON THE E-WASTE MANAGEMENT IN THE COUNTRY WHICH IS SUMMARIZED IN THE RECOMMENDATION BELONGS:

7.1. Tax incentive may be considered to telecom product manufacturing companies which institute environmentally safe production systems and products, to offset any incremental cost involved in the process. Tax incentive may be given to companies engaged in scientifically recycling of e-waste till end of life of the product.

7.2. There is an urgent need of generating awareness among the people about the best practices for collection mechanism of e-waste, to be followed to avoid dumping of waste in landfills, and to channelize the waste through standard methods of e-waste disposal management.

7.3. All the equipment manufacturers, service providers and Government sectors should be mandated to spread awareness regarding hazards of e-waste. All the telecom equipment manufacturers specifically mobile hand set manufacturers should disclose to the customer harmful materials used in their products so as to make customers aware of safe disposal methods, through different media. They are also required to include, in their user manual, all the details of health hazards due to use of different hazardous materials in the product (if, any) and the

scientific methods for safe disposal at end of life product.

7.4. Telecom equipment manufacturers and service providers may be advised to create a set up within the organization for safe disposal of e-waste. Providing training and education to the people engaged in recycling, recovery of material and safe disposal of e-waste may also be part of the duty of manufacturers and service providers under corporate social responsibility.

7.5. The concept of donating used EEE to the poor/ backward children for developing their skills is to be encouraged, mainly among schoolchildren and youth, which in turn will help in cleaning the environment.

7.6. Legislations for imports have Clear Guidelines regarding entry of hazardous substances along with the import of products. If required appropriate legislative measures may need to be taken.

7.7. As the waste disposal is a subject of state, municipal authorities in each city may also be entrusted with the job of collection of e-waste and its disposal in accordance with the guidelines and coordination with State Pollution Control Board which in turn can be transported to the recycler for proper management in environment friendly way.

7.8. Collection and maintenance of data on e-waste is extremely important to start corrective actions on policy and implementation. For e-waste management, there is a need for conducting assessment of e-waste generation, and formulation of standards and specifications for processing and recycling e-waste.

7.9. Finally, Case studies in different areas depending on socio economic conditions may be started for sustainable decisions in respect of e-waste management.

Abbreviations	
BFRs	Brominated Flame Retardants
CRC	computer refurbishing centers
CFC	Chlorofluorocarbon
CPCB	Central Pollution Control Board
EEE	Electrical and electronic equipment
EPR	Extended Producer Responsibility
e-waste	e-waste" refers to electronic waste (computers, printed circuit boards, cell phones, flat screen monitors, CRTs, etc.).
GHG	Greenhouse Gas
GeSI	Global sustainability Initiative
Gtz	GesellschaftfürTechnischeZusammenarbeit GmbH, Game Trading Zone
ICT	"Information and Communication Technologies." -ICT technologies that provide access to information Telecommunications.
KPIs	Key Performance Indicators
MAIT	Manufacturers Association of Information Technology
MPPI	Mobile Phone Partnership Initiative
MoEF	Ministry of Environment and Forests
PCB	Polychlorinated biphenyls

PVC	Polyvinyl Chloride
PACE	Partnership for Action on Computing Equipment
RoHS	Restriction on hazardous substances
RET	Renewable Energy Technology
SPCBs	State Pollution Control Board
St EP	Solving the e-waste Problem
UNDP	United Nations Development Program
UNEP	United Nations Environment program
WEEE	Waste Electrical and Electronic Equipment

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