TOWARDS SUSTANABLE E-WASTE MANAGEMENT IN SOUTH AFRICA

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ABSTRACT:

At the end of life, electronic waste (e-waste) eventually find their way into landfills and are even exported to third-world countries which use primeval recycling methods that have an impact on the environment. To address potential environmental problems that could stem from improper management of e-waste, many countries and organizations have drafted national legislation to improve the reuse, recycling and other forms of material recovery from e-waste to reduce the amount disposed in landfills.

The South African Government states in its National Waste Management Strategy (2011) that there is an increased complexity in the waste streams that are sent to landfills and that e-waste containg hazardous componets found to be mixed with general waste. This strategy document further mentions that it is not required by law for e-waste generating industries to submit e-waste data, making available information unreliable and contradictory. The limited understanding of the complex composition of the e-waste stream couse inaccurate information on the actual amount of e-waste generated in South Africa. Characterization of the e-waste stream is of paramount importance for developing a sustainable cost-effective and environmentally sound e-waste management strategy.

The purpose of the study was to improve the understanding of the e-waste stream and the effect on health and the environment. This study provides an overview of e-waste recycling, including a description of how it is generated and classified, strategies and technologies for recovering materials and new scientific developments related to these activities.

This methodology used in this study was fundamentally through literature review of studies from public and private entities, legislation and reports with resepct to e-waste management. Methods of recycling were examined as well as the hazardous composition of e-waste components and the effect on the environment.

The findings of this study indicated that the South African legislation should be addressing e-waste as a separate waste stream and that the e-waste disposal industry in South Africa should be developed to a level where employment and e-waste volumes are increased through the awareness of e-waste disposal.

Keywords

Municipal Solid Waste, e-waste, hazardous waste, recycling.

1. INTRODUCTION

There is no international definition of the term e-waste, and it appears that each jurisdiction adopts a working definition of the term in line with prevailing circumstances surrounding the production, importation and handling of electrical and electronic equipment. For the purpose of this study the same definition of e-waste as stated by Widmer and Lombard [1] on their assessment of e-waste in South Africa as being “any old, end-of-life electronic appliances, which have been disposed of by their original users”. E-waste (electronic & electrical waste) gemrally includes computers, entertainment electronics, mobile phones, household appliances

and less obvious items such as fluorescent tubes, batteries and battery-operated goods that have been discarded by their original users. Various studies have identified the possible harm that components inside e-waste hold for human health and the environmental. The possible harm e-waste holds is unleashed when it enters landfills where it exposes informal collectors, staff of the landfills and underground water sources to the various pollutants found in e-waste.

To control the escalating problem of e-waste, various countries captured their concerns and solutions in the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes, and their Disposal (Basil Convention) regulates the global control and transboundary movement of hazardous waste.

The European Community formed additional guidelines such as the Waste Electrical and Electronic Equipment (WEEE) and the Removal of Hazardous Substances (ROHS). These guidelines inform manufacturers on the types of substances that must be removed from their products if they wished to sell it to European countries. To address short comings in the Basel Convention, African countries created the Bamako Convention for complete banning of hazardous substances such as e-waste into Africa. South Africa has ratified the Basel Convention, however did not yet ratify the Bamako Convention. South Africas e-waste management is currently (2017) subsumed and regulated under the general waste management law – the National Environmental Management: Waste Act 2008 and the amended National Environmental Management: Waste Amendment Act, 26 of 2014.

South Africa is a middle-income country that produces significant amounts of e-waste and viewd by Arican countries as a leader on the continent for developing rational and sustainable waste management practices. Most of out Africa's electrical and electronic goods are imported through direct purchase, second-hand purchase and donations from developed countries [2].

The e-waste recycling process is also complicated by legislation that does not address e-waste directly, but rather addresses hazardous waste, general waste and the requirements for their disposal. Draft Waste Classification Legislation currently under review (2017) states that electrical and electronic waste will be classified as hazardous waste in the future once the legislation has been approved. It is understood from interviews with e-waste recycling companies that the South African Government is attempting to address the e-waste problem in new legislation on which they are currently receiving input from various industries throughout the country.

The South African Government states in the National Waste Management Strategy [3] that there is an increased complexity in the waste streams that are sent to landfills and that hazardous waste is found to be mixed with general waste.

Figures given by Enviroserve (a private lanfill managment company in South Africa) has placed hazardous waste disposal to general purpose landfill sites at approximately 5%. According to this statistic, hazardous waste amounts to approximately 30 000 tons per year (2010) at one landfill site alone that is being managed by Enviroserve and this number is on the increase. Typical landfilling disposal fees (2013) range from R100-R150/T for general waste, up to R600-R800/T for hazardous waste [4].

It is hoewever estimated, in a study funded by by Hewlett-Packard in 2009 that South Africa generates more than 100 000 tonnes of e-waste per year, with formal recyclers processing approximately 20% of this [5]. The remainder is either stored by the owner, recycled informally, added to the domestic waste stream, or dumped illegally [6].

The study aims to understand the e-waste handling practices in South Africa towards proposing susainable intergrated e-waste management. This data collected is intended to serve as background on the various processes in e-waste recycling and may be used for the development of generic e-waste mamagement guidelines to be used by small business

entrpreneurs to compete in the e-waste sector. This study covered the various sources of e-waste, the activities that are required to process waste, the output from these e-waste processes and legislation that impacts on e-waste in South Africa.

From the literature review it was also noticed that South Africa has some better developed recycling facilities with reference to the rest of the African continent. However due to the absence of adequate take-back centres for consumers and the lack of financing mechanisms for recyclers only an estimated 20% e-waste finds its way to recyclers.

2. RESEARCH METHODOLOGY

This study was conducted in order to assess the practices and strategies used in e-waste management in South Africa. In order to gather the nesessary data , the authors evaluated literature that are involved in e-waste and hazardous waste management or recycling processes.

Sources of information included the UNEP, StEP, Department of Environmental Affairs of the Republic of South Africa (DEA), publications from journals and case studies. The data collected in these documents served as the baseline for conducting interviews with companies in South Africa involved in the collection, dismantling and shredding of e-waste. Estimates that were listed in the literature study did not give an accurate estimate of the size of the e-waste problem and industry in South Africa. Unfortunately there is not enough statistics available from landfills that focus directly on e-waste as part of the waste stream to accurately predict the amount of waste that is available to e-waste recyclers. It was hoped that interviews with e-waste recycling companies in South Africa could clarify the issue on the amount of e-waste that is disposed of by consumers, but this remained a difficult estimate to confirm.

Participant recruitment is a major challenge in collecting data on e-waste recycling as many participants are not willing to discuss the way they collect, dismantle and shred e-waste. Recruitement involved a number of activities such as; identifying participants through association websites, news articles, business directories and search engines. Companies that advertise that they manage e-waste were approached via e-mail, company website response forms, and telephone to participate in the interview process. All the participants are owners of e-waste handling business.

Face-to-face interviews were conducted on the premises of the participants to allow the authors to observe the surroundings in which the company is performing their e-waste recycling process. Due to financial and time contaraints interviews and site visits were limited to the Gauteng province. Participants were informed that their information will remain confidential. It was also explained to participants that the purpose of the study was to determine what the current e-waste recycling situation in South Africa is.

3. STATUS OF E-WASTE MANAGMENT IN SOUTH AFRICA

3.1. Sources of e-Waste

It is important to note that South Africa does not support the importation of e-waste. Participants in the study however indicated that an increase in e-waste is required for sustainable business growth. According to the Basel Convention Country Fact Sheet on South

Africa (2011) waste from SADC countries that do not have the required facilities to dispose of the waste in an environmentally sound manner may be imported.

Not all imported used electronic goods are classified as waste by the exporter and importer. Goods that are still functioning but nearing the end of life are imported as second-hand goods. On request of the South African Government all waste shipped from OECD countries to non OECD countries should fall under the provision of the Basel Convention. South Africa will thus allow importation for the purpose of recovery if the importing company can provide proof of technology and means of environmentally sound waste management. The transit of hazardous waste is restricted in South Africa and this restriction covers all the countries that are parties to the Basel Convention. Article 11 of the Basel Convention however allows South Africa companies to trade in hazardous waste where it is proven that the country of origin does not have the facilities to process e-waste in an environmentally sound manner. This allows South African companies that have the necessary equipment to import and process e-waste locally. None of the participants indicated that they were importing e-waste.

Participants indicated that e-waste is mostly collected from corporate consumers and private consumers (households) through the placement of advertisements, word-of-mouth from previous customers, tendering at companies for disposal of e-waste and local collection drives. There is also a waste stream coming from landfills that are collected by the informal sector of collectors. It should be noted that the Second-Hand Goods Act 2009 (Act 6 of 2009) stipulated the procedures that must be followed when goods are acquired and disposed of by dealers in e-waste. This includes details of the product being sold, transaction and the seller's details.

3.2 E-waste handling

The collection process starts with the collection company contacting or being contacted by the e-waste generator (household or business) wishing to dispose of their e-waste. The e-waste collector evaluates the e-waste that must be collected and indicates if the e-waste generator will receive or make a payment for the removal of the e-waste. Payments are determined based on the weight of valuable material or re-usable items that can be recovered from the e-waste. Participants indicated that collection of e-waste from businesses resulted in the highest number of goods that could be refurbished or re-used.

It was not possible to determine the exact amount required for a collection company to sustain business, however the priciple is to keep overheads low and the ability to acquire high value e-waste items that contain various materials listed on the London Metals Exchange (LME) and prices paid for by downstream processors in the scrap industry.

Valuable metals that can be recovered include copper, aluminium, lead, etc and prices fluctuate according to international demand for metals. Prices for goods are based on unit weight or the numbers of units, such as number of computer cases or monitors. Products that still function are also resold as second hand goods by the collector.

Goods that requires further processing to separate valuable and non-valuable material is sent to facilities that dismantle e-waste or processed further by the collection company themselves. Separated waste has a higher value due to the amount of labour that went in to the process to separate material.

All indicated that some e-waste items such as batteries are sent to facilities that specialises in the disposal of the hazardous chemicals inside the battery.

Waste collection and storage is regulated by the National Environmental Management: Waste Act (Act 62 of 2008). E-waste is not specifically addressed in the Act but is currently

broadly classified as hazardous waste in South Africa.

The process of dismantling e-waste is a manual process where fastening devices such as screws, bolts, etc. on equipment are loosened to disassemble the product into its subcomponents used to manufacture the end product. These subcomponents are made of valuable material such as copper, aluminium, plastics, and other material that are listed by the Institute of Scrap Recycling Industries [7] and classified by the South African National Standard Globally Harmonized System of Classification and Labelling of Chemicals (SANS 10234). Tools used for this process are standard hand tools that are available at hardware stores such as screwdrivers, hammers, pliers and wire cutters. Once these subcomponents have been separated into categories of valuable (ferrous and nonferrous metals) and non-valuable materials (some plastics contain flame retardants that cannot be recycled), they are stored in containers that will later be sold to companies that shred or granulate waste, scrap metal dealers, intermediaries that export or material is sold directly to foundries. Non-valuable or non-recyclable materials are disposed of by specialised facilities or at hazardous waste landfill sites.

Figure 1 illustrates the typical componets retrieved from a computer during the demanufactoring process. Table 1 contains the typical current trading values. Prices paid by recyclers vary greatly, depending on the company, geographic region, quality of recyclables, prevailing markets and whether recyclables are received loose or in bulk.

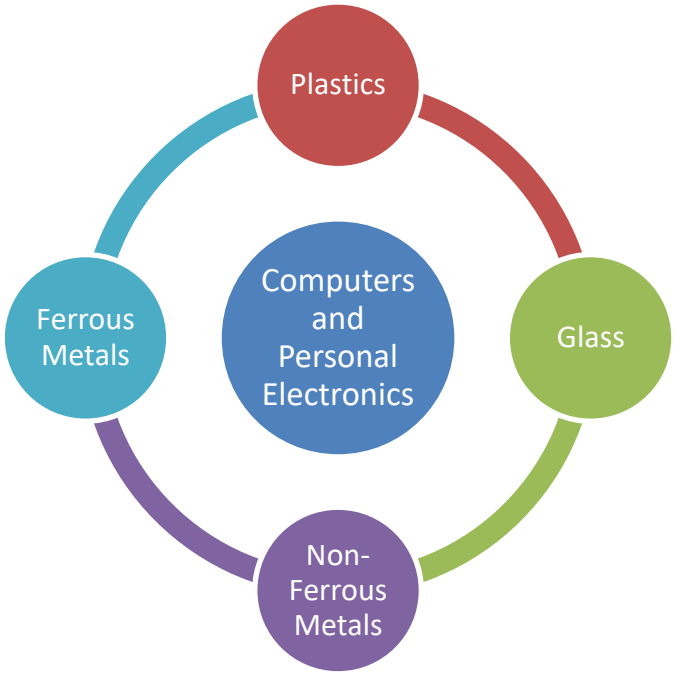

Figure 1: Deconstruction of Computers and Personal Electronics

Table 1: Typical prices paid per item by dealers as collected on 11 May 2017

Waste Item	**Price per kilogram in ZAR (South African Rand)**
Motherboards	10 to 33
Central Processing Units	800
Central Processing Unit	1200

Double	
Hard drives (Complete)	10
CD Rom Drives	1
Batteries (Lead)	4
Computer Power Supplies	1.50
Mixed E-Waste	3
Circuit Breakers	3
Copper	45
Electronic Waste	1
Laptop Charger	1.20
Laptop	2.50
Cellphone Boards	200
PCB – Harddrive	50

3.3 E-Waste Value Chain

As agreed during the interviews no participant will be named in this study to ensure that data remains confidential. The businesses of the participants ranged in size from 2 to 25 staff members and had turnovers of between ZAR500 000 and ZAR15 million per annum. E-waste types recycled ranged anything from computers to televisions with a monthly processing weight of between 10 tons and 400 tons. Based on the data collected the value chain illustrated in figure 2 could be established to show the flow of e-waste through the different processes of input, transformation and output. The majority of the participants indicated that are also involved in the demanufactoring of e-waste. Beyond the dismantling process companies dealt with much larger tonnages of e-waste and the focus shifts from separation to one of shredding or granulation. This is done for the purpose of transportation or further processing to extract valuable metals from material such as printed circuit boards found in electronic products. Further processing is done by foundries and specialised waste management plants that use chemical processes for further processing. It is important to note the significant role that refurbished goods have to play as a source of income to the waste collection and dismantling companies.

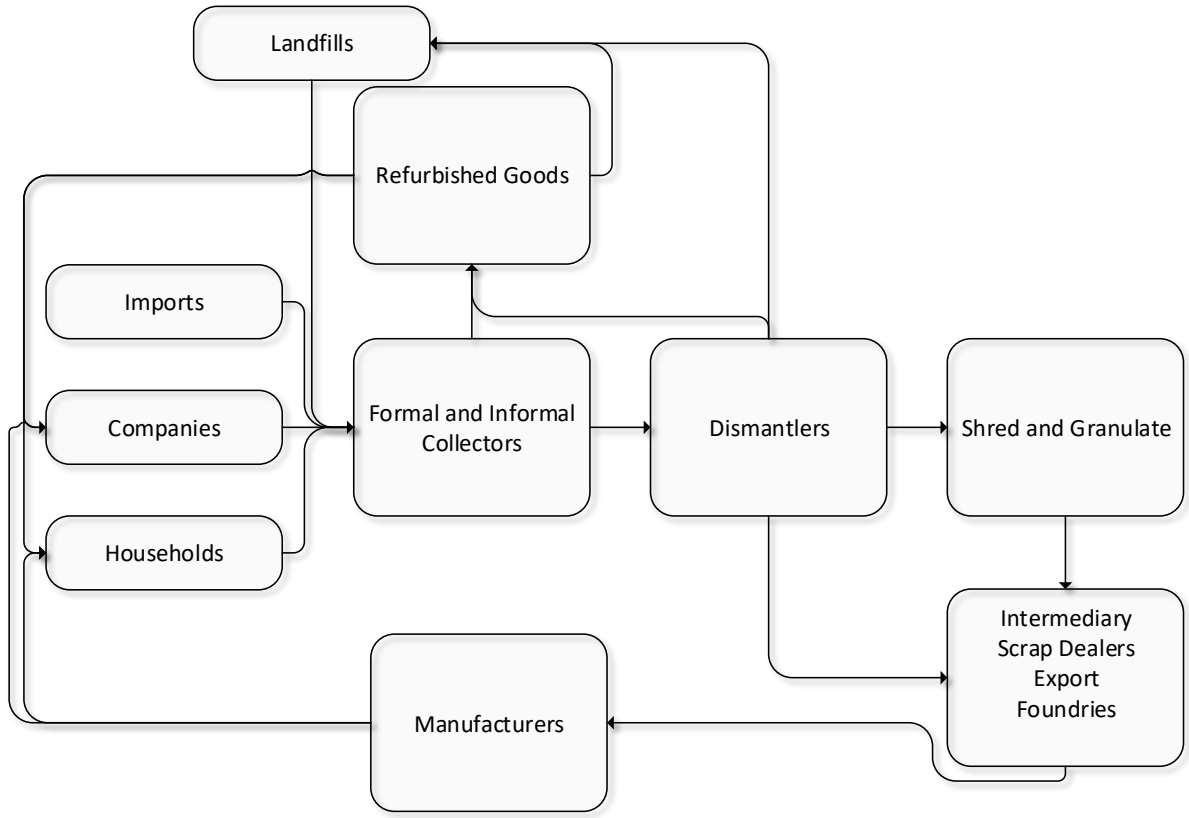

Figure 2: Flow of e-waste through the different processes

The exact number of companies in the e-waste collection and dismantling portion of the value chain is not known. No database was found that focuses specifically on these businesses as e-waste dismantlers or collectors and companies are not listed in all contact directories making accurate estimations of the size of the industry difficult. E-waste is also handled by companies that collect general waste, and these services are not advertised or listed as a separate service for e-waste collection. According to Keith Anderson (chairman of the e-Waste Association of SA (eWasa)), e-waste is growing five times faster than other sources, because more people are buying electronic goods and the lifespan of some items is decreasing. SA's e-waste market is about ZAR3bn. eWasa has 1 000 collection points for electronic devices and less than 100 recycling centres across SA. The e-waste industry would need at least four times more recycling centres to cater for the rise in the number of devices and household electrical items that are being discarded in SA [8].

Equipment that can be repaired is reconditioned and resold. The reconditioning process involves testing, upgrading and various other techniques to make the product almost fully functional and ready for the retail or consumer market. Products that have no value to the dismantler are land filled, but it has been indicated by those interviewed to be a low amount of the total waste collected. This could be due to the objective of maximising value extraction from the collected waste material.

Due to the simple nature and ease of the disassembly process, employees in dismantling facilities are not required to be highly skilled unless they are used on the recovery of items such as computer systems. Training occurs in-house though on the job training to acquire the required skills needed for recovery processes. Employees are mainly trained on basic skills such as proper use of tools and in cases where equipment must be recovered skills in computer repairs and more advanced fault finding skills are required.

Materials that cannot be dismantled further by the dismantling companies are sent to facilities that shred or granulate waste using industrial shredding equipment. The process starts with low skilled workers (similar to the dismantlers) sorting e-waste into various categories.

The objective of shredding is to reduce the size of the fractions, therefore maximising the amount of space that can be used for shipping the e-waste fractions to downstream processors. These fractions have to be processed further to extract the metals that are embedded inside products such as printed circuit boards found in electronic products.

From the interviews it was indicated that South African companies, that shred waste into fractions, use facilities in other non-African countries to process fractions further. This is due to a lack of specialised infrastructure in South Africa and other African countries that are capable of processing complex e-waste items such as Cathode Ray Tubes (CRT) that contain hazardous substances. The other issue to consider is that some forms of e-waste can become obsolete making specialised facilities unfeasible in the long run if they cannot be adapted to process new waste streams. An example of this is where Liquid Crystal Display (LCD) televisions and monitors are replacing the more traditional Cathode Ray Tube (CRT) technology. The impact is that we see a sharp decline in CRT but a sharp rise in LCD.
Participants in the interview process indicated that they only send or export waste to facilities that can deliver proof of ISO14001 status to ensure that waste will be processed further in an environmentally friendly and responsible manner.

3.4 E-waste: Refurbishing and re-use

Refurbished equipment is a significant contributor to the income of the participants interviewed. Participants indicated that demand in the secondary market for refurbished products is currently (2017) high due to the price gap between new products and refurbished products. Computers and white goods were the dominant products for which demand from consumers were the highest.

They indicated that they received equipment from various industries such as; mining, information technology, telecommunications. Before products may be resold they have to be cleaned, repaired and tested. In the case of companies that supply computer systems to recyclers, information remained a concern and they requested proof of data destruction stored on hard drives before the products may be re-used or sold. Participants indicated that the companies they deal with did not show a concern for how the waste will be disposed of further down the line. This may be due to the perception companies may have of dealing with a legitimate e-waste company and believing that these companies will act responsibly. Products such as; washing machines, copiers, fridges, televisions have a potential for refurbishment. Refurbished products are offered with a warranty to the end consumer and are regulated by the Consumer Protection Act 68 of 2008 and the Second-Hand Goods Act 6 of 2009.

E-waste collected that cannot be reused or cannot be separated into ferrous or non-ferrous metals are transported to facilities that can shred or granulate the e-waste further into small transportable fractions. These fractions are sold to foundries or exported to specialised facilities that extract valuable metals such as copper, gold and silver from the fractions.

Even with these processes there are still some forms of e-waste such as cathode ray tubes (CRT) that cannot be processed in this manner and requires shipment to specialised facilities in other countries for further processing. From interviews it is clear that South African companies do not have the technology to offer a cradle to grave solution on all forms of e-waste and thus relies on exportation of these items for safe disposal. Material that cannot be used in other processes is disposed of in landfills.

3.5 E-waste classification and legislation in South Africa

In SA, all waste including e-waste is classified as hazardous until proven otherwise by the generator of the waste in question [9]. Many substances contained in e-waste are considered Hazardous Waste and these are listed in the Basel Convention. South Africa is a party to the Convention. As a party to the convention the SA government is obliged to develop national legislation in line with the provisions of the convention.

South Africa has no legal framework which deals specifically with e-waste, howeveer legislation and guidelines dealing with Solid Waste and more specifically Hazardous Waste are in place and e-Waste is classified as Hazardous Waste [10]. More information on the Hazardous waste act may be found at the South African Waste Information Centre or Department of Environmental Affairs websites.

The European Union (EU) however does have a directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment, commonly referred to as the Restriction of Hazardous Substances Directive (RoHS) [11]. The RoHS directive is a set of criteria formulated by the EU to regulate the use of toxic materials in electrical and electronic devices. This Directive is aimed at eradicating certain hazardous substances from new electrical and electronic equipment. Producers of EEE within the scope of the Directive are responsible for ensuring that their products meet the requirements of the Directive. Furthermore, the act of placing a product on the market is a declaration by the producer that the product complies with the Directive. The RoHS requirements apply to end products that fall within the scope of the Directive. However, as a final product is made up of components and sub-assemblies it is inevitable that all components and sub-assemblies must not contain any of the restricted substances above the defined maximum concentration values. A technical file must be produced containing the analysis and component data and be kept for at least four years from the date the equipment was put on the market.

In SA waste can only be disposed of at a waste disposal facility that has a permit issued by the Minister of Water Affairs in terms of Section 20 of the Environment Conservation Act, 1989 (Act 73 of 1989). Such a facility must be sited, designed, operated and monitored strictly in accordance with the permit conditions. These conditions must include the requirements, standards and procedures set out in the Department's Waste Management Series, *"Minimum Requirements"* documents [12].

The President of South Africa signed *The National Environmental Management: Waste Bill* into an Act of Parliament in March 2009. The Act took effect from 01 July 2009. The purpose of the Act is to address the current fragmentation in waste legislation in SA [13]. A unique characteristic of the Act is that it attempts to ensure that Hazardous Wastes are governed, which will have the effect of tremendously increasing the volumes of Hazardous Wastes to be managed. The Act also commits SA to adopting a waste hierarchy in its approach to waste management, by promoting cleaner production, waste minimisation, re-use, recycling and waste treatment, with disposal seen as a last resort.

Once Hazardous Waste has been analysed, classified, and treated as required, the final step in the management chain is the disposal of the final waste product in terms of *The Minimum Requirements for the Handling, Classification and Disposal of Hazardous Wastes* [12]. The level of control and management required is determined by the hazard rating of the waste.

4. CONCLUSION

It is noticed that there is a general absence of infrastructure to deal with e-Waste in SA. Treatment and recycling is almost entirely a voluntary initiative either by individuals, organisations or small enterprises. It is however noticed that there is also support from local

authorities, although more active involvement is needed, either in the form of legislation or policies dealing specifically with e-Waste.

In its current state the wide definition of hazardous waste in the various pieces of legislation of SA is a source of confusion amongst consumers and recyclers. SA needs legislation that focuses specifically on e-waste and that addresses the process of disposal by generators of e-waste.

A fundamental problem is that e-Waste is not explicitly mentioned in any legislation, nor is it specifically identified anywhere as being hazardous. Aggravating the problem is the general lack of awareness by the public, and to an extent by authorities, regarding the nature and danger of e-Waste.

It is noticed that there is a general absence of infrastructure to deal with e-Waste, and to an extent its toxic components. Treatment and recycling is almost entirely a voluntary initiative either by individuals, organisations or small enterprises. It is however noticed that there is also support from local authorities, although more active involvement is needed, either in the form of legislation or policies dealing specifically with e-Waste.

According to the Minister Edna Molewa [14] there is a need for departments and organisations to stop functioning in Silo's and to coordinate efforts for maximum impact within the e-waste space. She also states that there is a great opportunity for job creation and economic development through recycling if a focus is placed on the collection, transpotation, sorting and recycling of the waste stream.

Broad information on the correct ways of disposing of e-waste must be promoted amongst comunities to educate them in the ways of disposing of e-waste in a responsible manner. Further awareness must be created to inform comunities of recycling companies that are currently recycling e-waste in their area and to what standards or legislation these companies must comply to to be seen as a responsible e-waste recycler. Industry associations can play an important role in the auditing and certification of facilities by verifying compliance to the various acts mentioned in this report.

At recycling companies, improved training programs are needed on legislation and guidelines for the proper disposal of e-waste to assist companies that deal with e-waste to comply to the requirements of their regional and national waste regulations. These guideline and training programs can assist companies to develop responsible recycling methods and facilities that may comply to certification under ISO 14001 standards. Compliance and certification could in future open doors for importation of e-waste to environmentally responsible recycling companies to extract valuable material in return for profits while reducing the impact that e-waste has on the environment.

South African companies has a well developed value chain that is successfully recycling e-waste from households, businesses and landfills. They are faced with the same resource constraints that most businesses face and face the same challenges of running their businesses. Capacity to process e-waste is not the main hurdle that these companies have to face, but rather access to e-waste that contains valuable material is hampering growth of the sector. Improved awareness programs and training will in future increase e-waste stream to recyclers thus reducing its impact on landfills and the environment.

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