A PROPOSED MODEL FOR SOUTH AFRICA TO EFFECTIVELY RECYCLE AND DISPOSE WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT

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ABSTRACT

In South Africa there are daily occurrences of dumping of Waste Electrical and Electronic Equipment (WEEE), also called e-waste, at municipal refuse sites. WEEE is hazardous and comes from households and businesses and these unhealthy and unsafe practices can lead to permanent damage of the soil and water resources of areas. It can cause humans and animals to acquire different kinds of cancers and illnesses which could ultimately lead to deaths. WEEE contains valuable materials that can be recycled and there is thus loss of potential extraction of these valuable materials. South Africa has a limited WEEE infrastructure to collect, refurbish, recycle, and disposal capabilities to handle e-waste and need a management model to address WEEE effectively.
1. **INTRODUCTION**

The retirement stage of any product, namely decommissioning and disposal, is of vital importance due to the increased awareness of environmental issues all around the world [1]. WEEE contains valuable materials and there is thus an opportunity for extraction of valuable materials. South African legislation regulating WEEE is vague and not specific causing confusion, hazardous practices, and minimal disposal and recycling. A country’s infrastructure, geography, legislation, social challenges, individual knowledge, etc. are drivers that necessitate a “custom made” model to dispose of e-waste effectively. There is a need for a model that suits the unique circumstances of the South African environment and a model to address the effective recycling and disposal issues will be proposed in this paper.

According to [2], South Africa is a signatory to the Basel Convention, an international treaty designed to reduce the movements of hazardous waste between nations. It is stated in [3] that South Africa is not a signatory to the Bamako convention which implies that South Africa can import e-waste legally. In [4] it is stated that in South Africa “…only a fraction of the discarded EEE (estimated 10%) finds its way to recyclers.” Authors [5] estimate that South Africa generates around 100,000 tons of e-waste annually of which only 20% is recycled by formal recyclers. Figures from [5] also indicate that that the South African average e-waste recycling is around 0.39 kg per capita per year, far below European countries. It is estimated by [6] that South African households have between 1,129,000 and 2,108,000 tons of potential e-waste which includes white goods, consumer electronics and IT. It is also estimated that around 70% of South Africa’s e-waste is in storage [7].

2. **IMPORTANCE OF MANAGING E-WASTE EFFECTIVELY**

In a study conducted by [8] a mathematical calculation concluded that the best methods for treating e-waste are *reuse* and *recycling*. A summary by [4] indicate that e-waste is an emerging problem as well as a business opportunity due to the value of materials. E-waste components are diverse and some are classified as “hazardous” because they go beyond the threshold quantities mentioned in the Material Safety Data Sheet (MSDS) [9]. The environmental and health effects such as asthmatic bronchitis and other allergic reactions, DNA damage, abdominal cramps, vomiting, diarrhea, nausea, decreased red and white blood cell production, abnormal heart rhythm, difficulties in breathing, increased or decreased blood pressure, numbness around the face, muscle weakness, and paralysis are highlighted by [10]. Some of the substances are known human carcinogens causing cancer and possibly death. Chlorofluorocarbons (CFC’s) used in refrigeration equipment also causes stratospheric ozone depletion and global warming [11].

3. **METHODOLOGY**

For this paper the following methodologies were implemented: The researcher did a literature review of e-waste practices in different countries. This included collection initiatives, recycling practices, legislation, extended producer responsibility, financing of e-waste, etc. The scenarios in South Africa were also investigated through a literature review. The researcher visited European recycling facilities and also visited South African entities such as municipal refuse sites, e-waste recyclers, government officials, environmentalists, etc. Observations were made at the different sites and informal discussions contributed to the development of a proposed e-waste management model as is discussed further in this paper. This proposed model is a first draft and will be adjusted where needed after scientific research data has been collected. The methodologies that will be implemented to collect the future data are: Quantitative data will be collected from South African consumers by using a survey questionnaire. Qualitative data will be collected from producers, retailers, recyclers, municipal refuse managers, government officials and environmentalists. Semi structured interviews will be conducted with knowledgeable representatives at these entities. The data will be analysed and a final e-waste management model will be proposed together with proposed legislation for South Africa.

4. **GENERIC E-WASTE MANAGEMENT FRAMEWORK**

This paper will continue the discussion under the following headings:

- Mechanisms to co-ordinate and drive the management processes
- Legislation
- Collection arrangements of e-waste
- Financing models for recycling e-waste

The framework will be expanded and discussed to highlight the important e-waste management points and to pave the way for a South African framework.
4.1 Mechanisms to co-ordinate and drive the management processes

**Basic drivers** - The conclusion from the literature is that different European countries have different levels of success with e-waste collection rates ranging from just above 1 kg/capita/year to 3.75 kg/capita (Switzerland) collected per year [12]. Switzerland is a world leader in effective e-waste but [13] states that although a system appears to be successful in some country the success of one system does not necessarily indicate success in another country due to different cultures, attitudes, social problems and behaviors, economic drivers, etc.

**EXTENDED PRODUCER RESPONSIBILITY** - Extended Producer Responsibility (EPR) is a strategy widely used around the world. EPR as a policy strategy was proposed by Thomas Lindqvist and introduced in 1990 [14]. EPR is defined as an “environmental protection strategy to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product. EPR is implemented through administrative, economic and informative instruments. The composition of these instruments determines the precise form of the Extended Producer Responsibility.” [14]. According to [15] policies on EPR had been introduced in European countries to achieve waste minimization.

**EPR in South Africa** - The ultimate responsibility of e-waste management must lie with the producers as it is the view of the researcher that the SA government should have the role as overseer and enforcer of legal action and that the SA government do not have the capacity, capabilities, or the knowledge to ensure the effective operation of a system of this magnitude. The Waste Act, [16], entered into force on 1 July 2009 and required the Minister of environmental affairs to draft a National Waste Management Strategy. The Framework for the National Waste Management Strategy specifically mentioned e-waste, and stated that it “should be prioritized for further investigation and implementation for extended producer responsibility”. In [2] it is stated “The responsibility of processing of e-waste in South Africa is not under the Extended Producer Responsibility (EPR) as what is now a practice in Europe.” The goal of EPR in South Africa should be on waste prevention (pollution reducing and preventing).

**STAKEHOLDER RESPONSIBILITY** - According to [17] the Japanese law on WEEE clearly stipulates the roles of each participant in the e-waste recycling chain. The Environmental Protection Administration of Taiwan (EPAT) created the 4-in-1 recycling program which consisted of community residents, private collectors and recyclers, municipal collection teams, and a recycling fund [18]. In [13] it is shown that in South Korea the EPR law came in effect in 2003 and local manufacturers, distributors and importers of consumer goods such as air conditioners, TVs and PCs are required to achieve official recycling targets or face financial consequences. Stakeholders are thus identified in EPR management programs.

**Stakeholder responsibility in South Africa** - A statement by [6] declares “a practical e-waste management solution which has the buy-in of all stakeholders” is needed.

**SYSTEMS COVERAGE AND ENSURING COMPLIANCE** - In [19] it is indicated that countries such as Belgium, the Netherlands, Sweden, Norway, and Switzerland had some form of legislation on e-waste even before the implementation of the WEEE Directive and made use of a Single National Compliance system covering all WEEE types. In a report [19] it is shown that at the time there were 76 compliance schemes in EU countries. In South Africa there is no systems coverage in place where e-waste is concerned. Compliance of effective recycling can thus not be ensured.

**REGISTRY** - Producers are defined on European, national and local levels due to the fact that sometimes manufacturers are or are not in the EU and producers could be wholesalers, distributors, retailers etc. depending on their status and position in the retailing chain [19]. In [2] it is suggested that “A single Registry would need to be set up and funded by producers”. At present no registry exists in South Africa.

4.2 Legislation

In a research survey conducted by [20] it was concluded that industrialists and academics perceived legislation to have the biggest industrial influence when designing environmentally conscious products. In a focus group study [21] point out that from the literature, legal and economic drivers have been identified as the strongest drivers.

**Some Asian countries** - It is pointed out in [4] that the Japanese Specified Home Appliances Recycling Act 1998 was published in 1998 and came into effect in April 2001. The act covers only TVs, refrigerators, washing machines and air conditioners and recycling is the responsibility of producers. A report [22] warns that India has tried to implement e-waste legislation without success. The Chinese WEEE legislation measures taken were summarized by [23] as well as some successes after implementation. In [24] mention is made that Indonesia has no regulation for managing the e-waste generated at homes. The Act on the Promotion of Saving and Recycling of Resources (APSRR) which regulates four types of home appliances in South Korea is mentioned in [25]. Personal computers were added to the program in 2003 followed by mobile phones and audio equipment (2005), and printers, copying machines and fax machines (2006). APSRR was replaced in 2008 with a new system called the Eco-Assurance System or EcoAS [25]. According to [18], Taiwan has EPAT that regulates and
ensures effective recycling of e-waste. According to Article 18 of the Waste Disposal Act, WEEE collection, storage and recycling must follow EPAT’s environmental and safety standards. These standards were issued in 2002 and revised in 2007 [18].

Europe-Legally, e-waste management was introduced in 1998 by the Swiss Federal Office for the Environment (FOEN), by way of the Ordinance on “The Return, the Taking Back and the Disposal of Electrical and Electronic Equipment (ORDEE)” [26]. Directives were drafted in Europe which required an environmental approach to all designs. The first one was the RoHS Directive 2002/95/EC. The second important directive is called the WEEE Directive 2002/96/EC and this directive (European Union, 2003b) requires producers in the EU member states to take back their products and dispose them using environmentally sound methods. A new Directive (2012/19/EU) requires the member states to achieve the collection rate of 45% by weight of weight of EEE put on the market in the three preceding years by 2016 [25].

America-Legislative activity in the US has rapidly increased [27]. According to [25], although no national law exists in North America, states, provinces and cities have implemented various measures to address the WEEE problem. According to [28] 25 states in the USA have some form of recycling program.

Developing countries-The 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (into force on 5 May 1992) is an international initiative to prevent the dumping of hazardous materials in developing countries, [29]. America is the only industrialized country in the world that is not a signatory to this convention [4]. To address shortcomings in the Basel Convention, African countries created the Bamako Convention for complete banning of hazardous substances such as e-waste. Referring to the Bamako convention [3] states that “these instruments share the common goal of controlling the movement of hazardous wastes across national borders”. The key issues of effective management of e-waste in developing countries are a change in attitude by governments, WEEE legislation, control of WEEE dumping, implementation of EPR, and the transfer of technology on sound recycling of e-waste [30]. A comment is made by [28], “There is currently no country in Latin America with a comprehensive e-waste management system”.

Legislation in South Africa-In 2007 (Updated in 2009) a report was compiled and released by Dittke, an attorney from Cape Town, to review the e-waste legislation in South Africa. The report stated that “Unlike many other countries, South Africa currently does not have any dedicated legislation dealing with e-waste. As such a whole range of environmental, as well as health and safety, laws must be examined to provide answers. Such investigation will have to cover national, provincial and local legislation. Needless to say, this is an arduous and unsatisfactory situation, and certainly does not help to clarify matters”, [31]. In [16] it is stated that mandatory Industry Waste Management Plans (IndWMPs) must be prepared for the lighting industry for mercury containing lamps e.g. compact fluorescent lamps (CFL’s). It also states that “Over the course of the next five years, IndWMP’s will be required for different forms of e-waste and batteries, and other waste streams that are best managed through an IndWMP.” Towards the end of 2013 a news release on the eWaste association of South Africa (eWasa) website stated: “As you may be aware e-waste has not been deemed a priority in terms of the waste act, therefore it was not mandatory for the sector to submit Industry Waste Management plans.”

4.3 Collection arrangements of e-waste


Composition of South African e-waste: A claim is made by [2] that the e-waste recycling systems are not uniform and sustainable solutions for materials such as CRT tubes, brominated plastics and printed circuit boards, have not yet been found.

Collection, number of collection points and efficiency of collection: In table 1 some countries with known collection points and recycling rate numbers per year are analyzed. For Norway and The Netherlands the first recycling rate per year could only be obtained for 2010 and it is assumed that the collection points did not change significantly. When analyzing the figures for the 4 countries (Ireland excluded) a coefficient of correlation of 0.75 was calculated if a comparison is made between the collection points and the total weight of WEEE being collected per year, indicating a very strong relationship.

<table>
<thead>
<tr>
<th>Country</th>
<th>Collection Points (All)</th>
<th>Recycle rate per year (Kg/p/y)</th>
<th>Population in millions</th>
<th>Persons/ collection point</th>
<th>Total weight in Kg per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway (2003)</td>
<td>400</td>
<td>13.41</td>
<td>4.5</td>
<td>11250</td>
<td>60345</td>
</tr>
<tr>
<td>The Netherlands (2003)</td>
<td>600</td>
<td>7.5</td>
<td>16</td>
<td>26667</td>
<td>120000</td>
</tr>
</tbody>
</table>
In calculating the coefficient of correlation of the recycling rate per person per year compared to the persons per collection point (PCP) in a country the figure is -0.70, indicating that if more collection points are available in a geographic area, the collection rate would increase. By including the four countries (Ireland excluded) in Table 1 a coefficient of correlation of 0.72 is obtained if the collection point numbers and the population of a country are analyzed. Although collection point numbers will not be only the determining factor of collection rate success, the number of collection points should play an important factor in collection efficiency.

Figure 1 shows the number of inhabitants per collection point on the Y axis and the collection in kg per inhabitant on the X axis. From the figure and the curve it can be derived that the less persons there are per collection point, meaning more collection points per persons, the better the collection rate will be. Spain has the least collection points per inhabitants and this is reflected in the collection return rate. From the key figures report released by [32] the data shows that all of the countries mentioned in Table 1 have increased the collection return rate except for Spain that shows a lower number of 2.91 kg/person collected in 2012 as compared to the rate of 3.3 kg/person being collected in 2007 [32]. The fewer collection points compared to the other mentioned countries could be a contributing factor.

Figure 1: Collection rate versus persons per collection point

<table>
<thead>
<tr>
<th>Country</th>
<th>PCP</th>
<th>R</th>
<th>GWP</th>
<th>2007 Collection Rate</th>
<th>2007 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>740</td>
<td>6.7</td>
<td>4.313</td>
<td>3.3</td>
<td>44.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>950</td>
<td>15.8</td>
<td>9.113</td>
<td>600</td>
<td>146850</td>
</tr>
<tr>
<td>Sweden</td>
<td>5828</td>
<td>28897</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Collection and number of collection points in South Africa** South Africa has approximately 51 million people [33]. Mention is made in [2] of some collection points but no exact figure is available. The same document lists a number of E-Waste consumer programs and drop-of points available in South Africa whereby the consumer can dispose of E-Waste responsibly. The researcher has found that some of the mentioned collection points are not collecting WEEE anymore (Pickitup) and that some do not know of collection initiatives (Builders Warehouse). Stores such as Pick and Pay and Woolworths only collect batteries, CFL’s and printer cartridges.

**4.4 Financing models for recycling e-waste**

Mention is made by [19] that even with the EU directives which indicate that producers must finance the costs of waste management there are different interpretations and promulgated legislation on the financing of new WEEE after 13 August 2005. Five financing mechanisms are described by [19] but the authors also state “the examples provided here are not an exhaustive list of possible models used for EPR programs”. In Japan the recycling fee and fund is managed by the Association for Electric Home Appliances (AEHA), [34]. It is the opinion of [17] that the majority of Japanese consumers disposes e-waste properly but is concerned that the recycling fee at disposal “may stimulate illegal dumping”. The South African environment does not have any financial model to assist with e-waste recycling and the focus of recyclers is mainly on the WEEE which is profitable when recycled.
5. **WEEE DESIGN AND TREATMENT SYSTEMS**

Since the realization of the hazardous nature of WEEE new measures were introduced in countries, especially in Asian and European countries to reduce the negative effect. Mentions were made of ROHS and design for environment (DfE) as measures to lessen the effects on the environment. In [18] it is explained that in Taiwan the recycling technologies for WEEE were developed using techniques from developed countries. As in many countries, WEEE recyclers in Taiwan focus on dismantling. It is the opinion of [17] that WEEE containing hazardous substances must be managed by accredited recycling plants in Japan. The results of previous research is used by [35] to indicate that vast quantities of e-waste are now being moved around the world for recycling in developing countries using manual processes in backyards of residential properties. South Africa is mentioned as one of the counties.

Where WEEE design and treatment systems for South Africa are concerned problematic practices associated with the environmental protection in South Africa are highlighted by [6]. Examples are one out of ten refurbishers and recyclers were ISO 14001 compliant, ozone-depleting practices, lack of disposal knowledge, etc. The same authors also highlight a key concern in the South African market as the potential threat of backyard electrochemical processes being set up.

6. **PROPOSED COLLECTION ARRANGEMENT FOR SOUTH AFRICA**

6.1 **Suggested collection point numbers for South Africa**

Statistical numbers suggest that the more the collection points, the better the success rate will be. The statistical website, [36], was accessed to determine the ten biggest city population figures in South Africa. From figure 1, using the formula PCP = 49286e°.1179 where R indicate the collection return rate in kg/person (assume 4kg/person), it can be calculated that a collection point must be set up for every 30865 persons. For Johannesburg (4434827), Cape Town (3740026), Tshwane (2921488) and EThekwini (Durban) (3442361) the collection points are calculated as 144, 121, 95, and 112 respectively. In the Tshwane metropolitan area the landfill sites and garden refuse transfer sites are 18 [37]. Potential retailers selling EEE are: 13 Pick and Pay stores [38], 9 Builders Warehouse stores [39], 23 Checkers and Checkers Hyper stores [40], 12 Shoprite stores [41], 3 Hi-Fi Corporation stores [42], 4 Deon Wired stores [43], 8 Game stores [44], and 21 Super Spar stores [45]. The minimum stores that can be used as collection points for the Tshwane Metropolitan area are thus 111 and the suggested 95 collection points are possible and achievable.

6.2 **Collection point placement**

It is proposed that collection initiatives are done at:

- EEE Retailers- Collect similar WEEE of EEE type being sold in the store.
- Public collection points-Municipal refuse sites and garden refuse sites.
- Free Call to collect-Set up in cities and bigger towns to collect large WEEE.
- Containers at apartments-To collect WEEE from tenants.
- Public collection boxes-To collect small WEEE from shops selling EEE.
- Special drop-off events- Bi-annually in rural areas and small towns.
- Corporate collection points (Not for large WEEE)-Hundred or more employees.

6.3 **South African collection infrastructure**

It is proposed that it must be in three groups, namely: 1-CRT’s, 2-all lamps, and 3-any other WEEE. Collection sites must have impermeable surfaces and must have weatherproof covering.

6.4 **Voluntary or mandatory program for South Africa**

A mandatory system is proposed. Producers have had many years of experience in other countries but have done little to start an effective e-waste management program.

6.5 **Take-back requirements in the South African environment**

All retailers of EEE should accept any similar WEEE irrespective if a customer buys a new product or not. All retailers selling EEE must accept WEEE with dimensions smaller than 30 cm³ without any obligation. Large enough shopping malls (> 50 000 m²) with more than 10% of retailers selling EEE must set up a manned WEEE collection point.

7. **ECONOMIC INSTRUMENTS TO FUND AN EPR PROGRAM IN SOUTH AFRICA**

The “polluter pays principle”, should apply and the South African consumer of EEE should pay for the recycling of WEEE. Currently no disposal fee is levied on any South African EEE item. It is proposed that an advance disposal fees (ADF) is levied on the sale of new EEE products to cover costs that arise from the implementing and administering of an EPR program. It is also proposed that an ADF fees should be levied on imported second hand items. The ADF fee structure must be an uncomplicated system to prevent confusion.
8. THE PRODUCER RESPONSIBILITY ORGANISATIONS (PRO) IN SOUTH AFRICA

The researcher proposes three different PRO’s. The first is for household appliances and electrical tools, excluding cooling appliances. The second is for information technology, telecommunications equipment and consumer equipment. The third one is for problematic equipment such as CRT, LED, LCD, cooling equipment, batteries, and different types of lighting equipment. From [46] the “Product structure” is proposed for PRO1, PRO2, and PRO3.

8.1 Detail setup of proposed PRO 1

PRO 1 for household appliances and electrical tools, excluding cooling appliances.

![Figure 2: Proposed PRO 1 model](image)

In figure 2 the proposed setup of PRO 1 should mainly focus to extract metals, aluminium, plastics, copper, glass, etc. as this equipment contains a minimum of electronic control parts/boards.

8.2 Detail setup of proposed PRO 2

It is proposed that PRO 2 should be for information technology, telecommunications equipment and consumer equipment.

![Figure 3: Proposed PRO 2 model](image)

In figure 3 the proposed setup of PRO 2 should focus on information technology (PC’s, notebooks, printers, etc.), telecommunication (cell phones, telephones, answering machines, etc.), and consumer equipment (Video recorders, smoke detectors, electric toys, video games, etc.). The suggested grouping is due to the high content PC boards in the equipment.

8.3 Detail setup of proposed PRO 3

PRO 3 should be for problematic equipment. Problematic equipment are televisions and monitors such as CRT, LED, LCD, plasma etc., all types of cooling equipment using refrigerants as the cooling medium, all types of batteries, and all different types of lighting equipment used by consumers.
In figure 4 each cluster will consist of producers of the same type of EEE being produced or imported. The products in this case have different applications, but generally they have the same properties. The producer clusters have the best knowledge on recycling of their products and communication from producers to recyclers and retailers (on recycling, handling and storage) is of extreme importance and is indicated by the broken line.

8.4 PRO’s and other stakeholders

In the entire proposed PRO models the following stakeholders need to be part of the group: Producers, retailers, recyclers, public representatives such as political party representatives, environmentalists, and government representatives.

9. THE PROPOSED MANAGEMENT BODY

The proposed name of the entity that will manage the WEEE process in South Africa is the South African Waste Electrical and Electronic Equipment Association (SAWEEEA). From [46] the “Functional structure” is proposed for the management body.

9.1 Composition and tasks of SAWEEEA

Figure 5 shows the proposed structure for SAWEEEA which consist of a board of members which are representing and selected by the three PRO’s. To prevent corruptive actions no employee of SAWEEEA must have any links to stakeholders which can cause undue influence in the operation of managing the WEEE in South Africa. SAWEEEA should be registered as a non-profit Section 21 company or similar.

9.2 Function of the five groupings under the SAWEEEA CEO

9.2.1 Logistics

This department should be involved in contracts for transporting of WEEE, monitoring of the operation of the auction houses (to be described in section 12), collection of WEEE, ensuring safe practices are applied at collection points, compile statistics (weights collected and of fractions), SAWEEEA infrastructure maintenance and setup, setting up of non-existing recycling facilities, setting up of an administrative system at collection points, etc.
9.2.2 Information Technology
This department should be involved in the design and setting up of a website for SAWEEEA in order to have retailers to report ADF amounts received, to have producers reporting ADF amounts and sales, maintain and upgrade the website, link to auction houses, implementing links on municipal websites, implementing links on government websites, and maintaining all SAWEEEA information technology networks.

9.2.3 Communication
This department should be involved in informing the public of the hazardous nature of WEEE, making the public aware of collection points and initiatives, implementing educational material on WEEE in school programs, provide feedback to stakeholders on the EPR program, communicate the applicable ADF fees to stakeholders, etc.

9.2.4 Finances
The financial department of the SAWEEEA team must be involved in determining the ADF fee in co-operation with all three PRO’s, receiving and comparing the ADF fee from producers and retailers, compensate recyclers of negative value items, compensate transport contractors, finance the setting up of collection facilities, finance the setting up of non-existing recycling facilities, payment of salaries of SAWEEEA employees, payment of operational expenses, payment for auditing of entities, etc.

9.2.5 Treatment/Accreditation
This department should issue and retract licenses to recycling facilities, assist in setting up of recycling facilities, audit recycled materials to prevent dumping, implement and upkeep the registry, ensure imported goods are RoHs compliant, etc.

9.3 EEE, ADF and ADF information flow

Figure 6: EEE, ADF and ADF information flow in proposed model

Figure 6 depicts the suggested flow of new EEE, the ADF fee, and ADF information flow. New EEE items are sold by producers to retailers. Producers can supply more than one retailer as indicated. The ADF on an EEE item is paid at the point of sale and received by the retailer. The ADF fee collected by the retailer must be paid to the producer/supplier of the item. Payment to the producer/supplier will thus become part of the transaction payment where the ADF fee will be additionally highlighted on the settling documentation. Producers should then transfer the ADF fees to the financial department of SAWEEEA. Retailers should record the ADF amounts received by consumers for specific items, and indicate from which producer the products were. Retailers should also provide this detail to SAWEEEA on a monthly basis as part of information flow. There will thus be a correlation between producers and retailers about ADF amounts received for recycling as well as detail information on the number of items and weight placed on the market. The customs department must also report figures to SAWEEEA on a regular basis. Information that must be supplied include number and dates of items that entered the customs points, the ADF fee received from producers/recyclers for second hand imported goods, and the payment of the ADF fee to SAWEEEA. In figure 6 Producer A represents an importer of second-hand EEE and an importer/manufacturer of new EEE. With all three entities reporting independently to SAWEEEA, fraud and free riding will be minimized due to the audit trail availability.

9.4 ADF and information flow for imported WEEE
South Africa is allowed to import e-waste. It is proposed that a SAWEESA official must inspect the WEEE upon arrival. If there is uncertainty about the status (WEEE or second hand EEE) the SAWEESA official must determine the ADF amount for EEE and payment must be done to SAWEEEA before the release of the containers at the ports or border posts. If the shipment is WEEE, a SAWEESA official (same or another) should inspect the shipment at the recycler premises to ensure that the shipment is
9.5 Financial (ADF) flow diagram

In figure 6 it has been shown that the ADF that was received from the customers, by the retailers, must be paid to producers which must again pay the ADF to SAWEEEA. In figure 7 below, the further proposed flow of the ADF fees is shown.

In Figure 7 the SAWEEEA head office is a single entity linking to an Auction house. In practice, more than one Auction house will be linked to SAWEEEA. ADF fees collected from the respective producers will be applied as shown in figure 7

![Diagram](image)

**Figure 7: Financial (ADF) flow diagram**

9.6 ADF and information flow for second hand EEE goods

Importers of second hand goods will have to pay exactly the same ADF fee as producers of new EEE. As in the case of imported WEEE, a SAWEEEA official should also inspect the shipment and determine the ADF before the items can be released. The costs involved with this inspection must be paid by the importer on top of the ADF amount.

9.7 Setup costs for the proposes model

With the introduction of laws that demand an ADF fee from consumers for recycling it should not be difficult to fund the expenses. The ADF fee will need to be introduced from a specified date after which the setup of Auction houses, collection points, SAWEEEA main office, etc. will commence. The physical collection, transportation, auctioning and recycling will thus follow at a later stage. With the introduction of the ADF fee, private or government loans could be secured to fund the setting up of the entire system.

10. PERFORMANCE STANDARDS – SETTING TARGETS IN SOUTH AFRICA FOR RE-USE, REFURBISH AND RECYCLING OF WEEE

If possible the life of consumable items must be extended through re-use. Refilling a printer cartridge is an example of re-usable consumable items. The refurbishment of equipment is a lucrative and live sector and there is no need to set standards in this sector. For recycling, no targets will be proposed as this is a consultation process between all stakeholders.

11. THE ROLE OF THE SOUTH AFRICAN NATIONAL GOVERNMENT

Government should establish a consultative framework and start by leading the process. Government must co-opt SAWEEEA to co-ordinate and run the day to day operation of the management system and set up a single legal policy framework which guide and support the implementation of an e-waste strategy. Government must set reasonable targets of WEEE collections and government must act as the enforcer of laws if not complied with.
11.1 Additional government/local government measures

The disposal of any WEEE onto landfills and into municipal refuse bins or bags, rivers, dams, any open area, or the sea must be banned in South Africa. The role of local government must be limited to the reception and storage of WEEE at municipal and garden refuse sites and to information communicated to the public.

12. CONSUMERS AND INCENTIVE SCHEMES

South Africa is a relatively poor country and it would be wise to incorporate incentive schemes to motivate consumers to hand in WEEE. Incentive schemes could possibly be the receiving of talk time or data bundles on cellular phones or data devices, points on reward card systems such as FNB’s eBucks points, Pick a Pay’s smart shopper cards points, Woolworths’s WRewards points, ABSA bank’s Rewards points, Standard bank’s UCount Rewards etc.

13. PROPOSED AUCTION HOUSE

In figure 8 the researcher is proposing an “Auction house” for WEEE recycling. An auction environment has benefits and fit into the proposed model. Klemperer (1999:227), state that “…auctions are such simple and well-defined economic environments”. The auction houses should be placed in the bigger cities/towns in South Africa close to recyclers. Johannesburg and surrounding areas, Cape Town, and Durban/Ballito/Pietermaritzburg area are proposed. Due to the fairly large distances between cities in South Africa the solution would be to have collections done at remote areas ones or twice per year using larger trucks to ensure single trips and economy of scale.

From [46] the “Process structure” is proposed for the auction house. Figure 8 shows two different flows namely that of information (the solid line) and material flow (the dotted line). The administrative section should be the center point of information. Collections, call-to-collect, and transport arrangements are done from this section and the number/weights of received WEEE and the income generated must be reported to SAWEeea. Auction details must be published through the administration department. The receiving, grouping and dispatching section must receive the collected WEEE from the transport companies, group the WEEE in different categories, separate items that can be refurbished and dispatch auctioned items. The auction section should deal with the auctioning of the WEEE. On auction days this section must ensure that bidders are registered, auction deposits are collected, terms of the auction are communicated, an auction list with available items is distributed and details of buyers of lots are captured.
14. PROPOSED ACCUMULATION STATIONS

In figure 9, accumulation stations must be located in areas (Polokwane, Nelspruit, Bloemfontein, Kimberley, George, etc.) where relatively large WEEE quantities can be collected but where very few recycling facilities can be found. Although rural areas are not seen as towns, there are some areas where large communities exist and the proposed Accumulation station could also be set up in these areas. The operation of the Accumulation station will be similar to the auction houses in the sense that the public and collection points will communicate with the Accumulation Station when WEEE must be collected. When enough material is available the WEEE will be transported to the auction houses. In rural areas the municipal refuse site, schools, community halls, etc. could act as the Accumulation Station to centralize collections. If recycling facilities are established near accumulation stations the selling price of WEEE items can be negotiated by using the market prices received at the auction houses. From [46] the “Process structure” is proposed for the accumulation stations.

15. FREE-RIDERS AND MEASURES TO PENALIZE FREE-RIDING

According to [47] “Free-riders” are actors, individuals or businesses, in an EPR system that does not pay for the benefits they receive. Free riders will always be part of any system but the existence of them should be limited. In the proposed model care was taken to minimize free-riders. The proposed measures to limit free riding of stakeholders are fines (continuous if no remedies occur), criminal charges and the termination of a business entity.

16. ORPHAN AND EXISTING PRODUCTS

“Orphan products” are products of which the producers are non-existent due to bankruptcy or some other reason while “Existing (pre-existing) products” (sometimes referred as “historic” items) are products on the market at the time the EPR policy is to be introduced [47]. Orphan and existing products are a reality in South Africa and the proposed management model includes orphaned and existing products that need to be recycled.

16.1 Financing options for addressing orphan and existing products

The proposed ADF fee which should be levied at the sale of new items will be used to fund the recycling efforts of end of life (EOL) equipment, regardless if the WEEE is orphan or existing/pre-existing products. New product sales should thus fund all current WEEE.

16.2 Non-recyclability of products

If a product is essential, non-recyclable, and the only product available in South Africa, the ADF fee must be set at a level that will ensure the product is safely discarded at a hazardous site. If there are alternative recyclable products on the market the non-recyclable product must be given a time period of two years to be changed to a recyclable product. If there is more than one alternative product the ADF fee should be the same for all similar products but the difference between the normal ADF fee and the cost to dispose of the non-recyclable item must be funded by the producer.

17. COMPETITION ISSUES

The proposed EPR model ensures fair competition in the import market, the product market, the recyclable materials market, the product collection (transport) market, and the recycler market,
18. WEEE DESIGN AND TREATMENT SYSTEMS IN SOUTH AFRICA

To eliminate problematic practices associated with the environmental protection in South Africa the researcher suggests: All refurbishers and recyclers must be ISO 14001 compliant, all recyclers must be in position of a Precious Metals Refining License, a waste transportation permit must be obtained which will allow a recycler/refurbisher to transport WEEE, a second hand goods license to enable the recycler/refurbisher to be in position of second hand goods, alternatively the above three license will be replaced by a SAWEEEA recycler license with a well-defined and specified recycling focus which enable recycling of precious metals, transportation of WEEE and of being in position of second hand goods.

19. FUTURE WORK

At publication of the paper the focus is on a proposed WEEE management model for South Africa. The proposed model was developed from literature reviews, observations, and informal discussions with stakeholders in the e-waste industry. Research is still in progress and thus no data can be provided to support the proposed model. Data will be collected during the second half of 2016 to test and validate the proposed model.

20. CONCLUSION

The environmental impact induced by WEEE and the value of the materials contained in WEEE need to be addressed in South Africa. Recycling efforts are mainly conducted for the financial benefit of recyclers while environmental problems are not addressed. To address the problems and opportunities it is vital to introduce legislation and a WEEE management model. Public awareness regarding environmental protection needs urgent attention to ensure the safe disposal of WEEE.

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