Closing The Loop Operating Guidelines

Work Package: WP2.3 Closing The Loop Operating Guidelines

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1 Acknowledgments

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Special thanks go to all, who contributed to the drafting of this document.

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2 List of acronyms

BAT  Best available technology
BFR  Brominated Flame Retardants
CFC  ChloroFluoroCarbon
CRT  Cathode Ray Tube
EAC  East African Community Trade Union
EACR East African Compliant Recycling
EEE  Electric and Electrical Equipment
EHS  Environmental Health and Safety
EPR  Extended Producer Responsibility
HCFC HydroChloroFluoCarbon
LCD  Liquid Crystal Display
Li   Lithium
NiCd Nickel Cadmium
NiMH Nickel Metal Hydride
PCB  PolyChlorinated Biphenyls
PoM  Put on Market
R&D  Research and Development
SFR  Solid Recovered Fuel
WEEE Waste Electric and Electrical Equipment
3 Foreword

All recommendations should not serve as a “do-it-yourself” guide to establish a Closed Loop circular economy solution for municipalities. They are based on the personal experiences of all participants of the Expert Modelling Workshop in establishing e-waste management systems in emerging economies taking into consideration legislative, economic and environmentally viable options per waste stream or fraction as applicable to a municipality to realise optimal value recovery within the municipality. As legislative and financing landscapes as well as technologies are developing rapidly, new solutions come out frequently.

4 Executive summary

This report summarizes the results of Workshop 2.3 Closing the Loop in Johannesburg (South Africa) gathering selected African and European experts in the framework of the EWIT project “Developing an e-waste implementation toolkit to support the recycling and the secondary raw material recovery strategies in metropolitan areas in Africa”, funded by Horizon 2020, a European Union Research and Innovation Programme. It focuses on evaluation of current and future possibilities to introduce a system that supports a circular economy, distributing the financial returns and burdens across the value chain of e-waste for four case municipalities. Based on the Master Plans completed in EWIT WP 1, Closing the Loop is seen inter-related with the deliverables in collection, technology as well as financing and legislation, as circular economic factors are a red-line across these pillars in effective e-waste management.

The circular economy, as defined by United Nations Environment Programme (2006), is

An economy which balances economic development with environmental and resources protection. It puts emphasis on the most efficient use and recycling of resources, and environmental protection. A Circular Economy features low consumption of energy, low emission of pollutants and high efficiency.
5 Scope of Closing the Loop

Figure 1: Circular economy flow chart

As the scope of the EWIT project is on e-waste management implementation, the focus of Closing the Loop workshop emphasized implementable improvements for the e-waste value chain to drive electronics into a collection streams for reuse, parts harvesting and eventually resource extraction.

The e-waste value chain starts with collection, continue with good recycling and it should be connected, according to a “circular economy” symbiotic vision, to selected end user industries that will benefit for the availability of secondary raw materials, better if placed in the local economies. Based on the base line scenario in each of the 4 African cities/counties (data gathering, the Twin City Workshops and the elaborated Master Plans) the viability of closed loop options per the following component and fraction streams, with a specific focus on environmental protection and economic in the region, have been proposed.

- Non-ferrous metals
- Ferrous metals
- Printed circuit boards
- Hi-tech plastics
- Brominated flame-retardant plastics
- CRT & Flat panel monitors
• Portable batteries
• Rare-earth elements¹
• Printer cartridges & toners
• Refrigerator foam
• Florescent tubes

In the framework of the EWIT project a series of 4 workshops were held with European and African experts on e-waste management. The outcomes of these workshops were an analysis of the unique situation facing each individual African municipality, appraising the available opportunities and knowledge and provide elements that will be used to define improved e-waste management given the background situation and constraints. Four specific themes for those workshops have been identified, each led by an Expert Leader:

**Workshop 1 Collection of e-waste in Africa:**

Expert Leader: UNA

Experts: ICRSD, BOKU, KSU, Ancitel E&A, UNIVLEEDS, QUADRIFOGLIO; Choma Municipal Council,

Invited Stakeholders: UNIDO, SAT, WorldLoop, Remedia, Mijikenda Youth Association, Kenya Youth Network

Main focus: Models and solutions to set up a simple, effective e-waste collection system in African cities, with the purpose of starting/ increasing the volumes of end of life electrical and electronic products available for recycling. Culture and behaviors will be taken into consideration, together with alternative collection models and infrastructure, communication and awareness rising initiatives and incentives for citizens to take back their e-waste.

**Workshop 2 Technology:**

Expert Leader: SAT

Experts: ICRSD/SICL, VUT/IWR, Mintek, BOKU invited Stakeholder: UNIDO, Remedia

Main focus: Evaluation of which, even basic, technology platform is now in place for dismantling and recycling of e-waste, and definition of how this can be enhanced in order to improve safety, environmental protection and job creation. This document does not address the further treatment of valuable and not valuable outputs of the treatment which is the focus of Close the Loop.

**Workshop 3 Closed Loop Models:**

Expert Leader: WorldLoop

Experts: BOKU, eWASA, ICRSD/SICL, ISWA, Mintek, KSU, SAT, UNIVLEEDS, Remedia

Main focus: The e-waste value chain starts with collection, continue with good recycling and it should be connected, according to a “circular economy” –symbiotic vision, to selected end

¹ Only considered in the case of Johannesburg Municipality due to technology available in Johannesburg and current discussions at policy level to improve recovery rare-earth elements.
user industries that will benefit for the availability of secondary raw materials, better if placed in the local economies. This workshop will focus on this specific opportunity.

**Workshop 4 Financing & Legislation:**

Expert Leader: EIEE


Main focus: Understanding the challenge of financial support for the development of smart e-waste management systems in Africa and the legislation framework in the African context, essential to enable the implementation of any identified solution.

This report summarizes the results of Workshop 3 Closing the Loop. It focuses therefore on connecting the e-waste value chain, according to a “circular economy” -symbiotic vision, to selected end user industries that will benefit from the reuse of equipment and later the availability of secondary raw materials, prioritizing the local economies if viable.

In the context that no local downstream market exists today nor economies of scale are able to be realised for a particular fraction or component, potential cooperation areas and shared solutions on a transnational level have been given in order to facilitate a system of equal distribution of financial returns and risks across the value chain.

Closing the Loop has to be seen in connection with the reports of the 3 other workshops on collection, technology as well as financing and legislation. Additionally, when considering closing the loop solutions, local habits and cultural traditions need to be considered.

6  Part 1

6.1 Introduction

According to the European Commission the global economy currently loses a significant potential of secondary raw materials which are found in waste streams.

In 2013, total waste generation in the EU amounted to approximately 2.5 billion tons of which 1.6 billion tons were not reused or recycled and therefore lost for the European economy. It is estimated that an additional 600 million tons could be recycled or reused. By way of example, only a limited share (43%) of the municipal waste generated in the EU was recycled, with the rest being landfilled (31%) or incinerated (26%). The EU thus misses out on significant opportunities to improve resource efficiency and create a more circular economy (European Commission).²

Such estimates are not available for the African economy, however with burning and primitive resource extraction processes being prevalent on the continent it can be inferred that Africa is also missing out on potentially economically attractive secondary raw materials that are lost through emissions or processing technologies. As such, Africa stands to see significant opportunities with the improvement of e-waste management systems.

Closing the Loop assessed the ability to introduce, promote or strengthen the delivery of a circular economy across the four municipalities identified by EWIT – Choma, Zambia; Kisii,

Kenya; Abidjan, Ivory Coast; and Johannesburg, South Africa. While the four African countries under the scope of EWIT are at various stages of establishing legal and financial frameworks, as well as local initiatives to address the challenge of the increasing flows of end-of-life electrical and electronics products, little to no emphasis has been placed on a holistic approach to product lifecycle management.

The EWIT consortium has assessed these components in their applicability to the context of the four municipalities chosen including a baseline assessment taking into consideration current legislation, geographical scope, industrial players, basic awareness, challenges and recommendations to assist in realizing closing the loop solutions. Because a true closed loop solution in the value chain for e-waste is highly dependent on the product, component and fraction, the following were identified for assessment per municipality:

- Non-ferrous metals
- Ferrous metals
- Printed circuit boards
- Hi-tech plastics
- Brominated flame-retardant plastics
- CRT & Flat panel monitors
- Portable batteries
- Rare-earth elements
- Printer cartridges & toners
- Refrigerator foam
- Florescent tubes

### 6.2 Closing the Loop in Choma

#### 6.2.1 Baseline scenario

**Table 1: Baseline scenario Choma, Zambia**

<table>
<thead>
<tr>
<th>Name of the District</th>
<th>Choma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Located along the main road and railway track between Livingstone (188km away) and Zambian capital of Lusaka (284km away)</td>
</tr>
<tr>
<td>Type of activity</td>
<td>District of Choma is the commercial hub for the central region of the province. Historically an agrarian society, Choma is considered a rural milieu with a civic centre and large rural distances between inhabitants. Choma is seeing an uptick in economic activities as commerce is diversifying, particularly for those close to the railways.</td>
</tr>
<tr>
<td>Population's residence</td>
<td>The majority of Choma’s population still lives in the rural outskirts of the city centre. Economically, much of the population currently is living below the poverty line and on government subsidies.</td>
</tr>
</tbody>
</table>

3 Only considered in the case of Johannesburg Municipality due to technology available in Johannesburg and current discussions at policy level to improve recovery rare-earth elements.
<table>
<thead>
<tr>
<th>Legislation (cfr WP 2.4 for complete details)</th>
<th>Choma adheres to the national regulation on waste management, overseen by ZEMA including:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- National Solid Waste Management Strategy (2004);</td>
<td></td>
</tr>
<tr>
<td>- National Water Supply, Sanitation and Solid Waste Management Policy (under development);</td>
<td></td>
</tr>
<tr>
<td>- The Environmental Management Act No 12 of 2011 which takes a supervisory role over local authorities on the transportation of waste and the operation of waste dumps</td>
<td></td>
</tr>
<tr>
<td>- The Local Government Act Cap 281, SI No. 100 of 2011 (SWM Reg. 11), which mandates Local Authorities (Las) to collect municipal solid waste</td>
<td></td>
</tr>
<tr>
<td>- Waste collection is undertaken by councils or subcontracted to the private sector</td>
<td></td>
</tr>
<tr>
<td>- Makes it mandatory for residents to use and pay for solid waste management services</td>
<td></td>
</tr>
</tbody>
</table>

In specific context to e-waste management and Closing the Loop for Choma, as Choma's economic activities increase, waste and e-waste volumes are anticipated to increase as well.

The United Nations University estimated an average per capita generation of e-waste in Zambia at 0.9 kg in 2014 (Baldé et al., 2015). Applying this generation rate, the amount of e-waste generated in total in the District of Choma would be approximately 220 tons in that year, the location and destination of which are unknown.

There is no legislation dedicated to e-waste management, nor financing model introduced at this time, however Zambia has ratified the Basel Convention and Amendment, which may have a future impact on upstream and downstream markets. Current e-waste collection is done together with municipal waste, which gets manually loaded into a small waste collection truck, and dumped at a designated area. Pickers go through and collect material for resale. Burning is also a common solution.

E-waste collectors also go to households to purchase salvageable equipment which get sold to local repair and refurbishing shops (currently 2 active in Choma focusing primarily on IT). There is no e-waste dismantling currently available in Choma however a secondary raw material market does exist for certain plastics and metals.

Public awareness on e-waste management is quite low, while the governmental agencies are increasing their proficiency however overall awareness of Closing the Loop solutions is low at the governmental and public levels alike.

Due to the geographical location of Choma and access to road and train infrastructure, as well as local mining industry, there are downstream solutions for collected and sorted e-waste from Choma.

6.2.2 Challenges and opportunities

Choma faces a number of challenges to realize a local closed loop solution with an emphasis on an e-waste management system for equal financial distribution across the value chain. These challenges are listed below in detail, followed by specific opportunities available to Choma.
- **COLLECTION**: As detailed in WP2.1 Collection, volumes of general e-waste collection are low, limiting Choma’s ability to currently realize economies of scale necessary to justify dedicated infrastructural investment for dismantling and treatment technology. The current collection vehicles, including manual loading are not the most efficient mode of collection to increase volumes for municipal waste or e-waste collection (cfr. WP2.2 Technology Operating Guidelines for further information on technology recommendations).

In addition to the low volumes, Choma faces contamination risks of streams as the current collection/storage processes does not include any pre-sorting or separate collection. This also articulates another challenge, that there is no current sound disposal option for hazardous material thus these materials may either be disposed of illegally or stay in the secondary raw material.

- **LOGISTICS**: Additionally, current logistics challenges for closed loop e-waste management, to enable equal distribution across the value chain in Choma include poor road infrastructure to enable collection and transport as well as high export costs to existing markets outside of Zambia.

- **STAKEHOLDER ENGAGEMENT**: Currently there is limited exchange between academia, policy makers and industry including the mining sector. As a focus on urban mining increases, it could be perceived as a commercial threat to the existing mining industry in Zambia. There is low awareness on Closed Loop / Circular economic solutions at the government level. As the primary focus on waste management today is on collection, the repair shops can play a valuable role in the value chain.

- **FINANCING & LEGISLATION**: The absence of legislation on e-waste management or circular economy and limited implementation of current waste management legislation without a financing mechanism make it challenging to support the collection and proper treatment of all fractions from e-waste. Additionally, current export license fees restrict access to potential downstream markets. Zambia also has limited regulations on what material can be imported as new or reused products. This may introduce products with low performance life and containing difficult to dispose of hazardous material.

In light of the challenges described, ample opportunities also exist. Due to low volumes of e-waste currently present in Choma, the municipality is in the unique position to start drawing up solutions to reinforce a Closed Loop system, before e-waste becomes an overwhelming economic and environmental issue.

- **LOCAL KNOWLEDGE & EXPERTISE**: Choma government has participated in multiple capacity building activities on e-waste management, the EWIT project notwithstanding, thus local knowledge in Choma and at a national level is growing. Additionally, academic institutions in the country have a focus on environmental studies and the mining industry has extraction and treatment knowledge that can be applied to urban mining. Local repair shops have basic IT knowledge that can be further developed and through partnerships, apprenticeship programs could be established to engage with the currently available low-skilled, large labour force.

- **ACCESS TO MARKETS**: In addition to the local repair shops, integrating REUSE into the electronics value chain, Choma also has access to scrap metal and plastic
dealers as well as downstream market access to dismantlers in Lusaka. Additionally Choma is able to access international markets as there are no current restrictions placed on export.

6.2.3 Solutions and strategies

General solutions and strategies for Choma that can be implemented today include the following. This list is not exhaustive and as Choma’s waste volumes increase the legislative and financial system is put in place, additional solutions can become available at a more localized level:

- Increased awareness at the policy maker level as well as amongst the general public for e-waste management and closing loop opportunities.

- Improved collection, separation and storage of WEEE. These first steps will reduce exposure and environmental risks and draw efficiencies in resource recovery and reusability.

- Stakeholder engagement, particularly with the ministries of mining, trade/industry, environmental affairs, and ICT to start a dialog on circular economy solutions for electronics within Zambia and particularly the role Choma can play in the value chain. Additionally, strengthen the relationship and identify potential synergies of the mining industry in Zambia and academia to identify more local downstream secondary markets for resource extraction from obsolete WEEE.

- Improve training at repair facilities and introduce health and safety measures for the workers.

- Develop a logistical flow of obsolete equipment to be delivered to a centralized dismantling and pre-processing facility in Lusaka.

Table 2: Recommendations per fraction stream for Choma

Closing the Loop takes into consideration systematic approaches that can be introduced to as defined above, pragmatic solutions for the key fractions and components have been evaluated given Choma’s current state of e-waste management.

| Non-ferrous metals | - Encourage utilization of local market available  
|                    | - Gain better understanding of volumes and flows  
|                    | - Targeted training for labour force |
| Ferrous metals     | - Encourage utilization of local market available  
|                    | - Gain better understanding of volumes and flows  |
| PCBs              | - Unknown market available  
<p>|                   | - Enable export under fair trade conditions (cfr 7.1.3)  |
| Hi-tech plastics   | - Encourage utilization of local market available  |</p>
<table>
<thead>
<tr>
<th>BFR plastics</th>
<th>Promote sorting /differentiation of plastics by stream and colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Explore R&amp;D potential for new uses in production</td>
</tr>
<tr>
<td>CRT / flat panel monitors</td>
<td>Separate collection, safe, secure storage</td>
</tr>
<tr>
<td></td>
<td>Send to permitted facilities dismantling centre</td>
</tr>
<tr>
<td></td>
<td>Enable export under fair trade conditions (cfr 7.1.3)</td>
</tr>
<tr>
<td>Batteries (portable)</td>
<td>Separate collection, safe, secure storage</td>
</tr>
<tr>
<td></td>
<td>Send to permitted facilities</td>
</tr>
<tr>
<td></td>
<td>Enable export under fair trade conditions (cfr 7.1.3)</td>
</tr>
<tr>
<td></td>
<td>Start monitoring data to see potential future market opportunities</td>
</tr>
<tr>
<td>Cartridges</td>
<td>Explore local reuse/refilling options</td>
</tr>
<tr>
<td></td>
<td>Send to permitted facilities</td>
</tr>
<tr>
<td></td>
<td>Enable export under fair trade conditions (cfr 7.1.3)</td>
</tr>
<tr>
<td>Fridge foam</td>
<td>Separate collection, safe, secure storage</td>
</tr>
<tr>
<td></td>
<td>Remove doors of refrigerators prior to disposal/storage</td>
</tr>
<tr>
<td></td>
<td>Send to permitted facilities</td>
</tr>
<tr>
<td></td>
<td>Enable export under fair trade conditions (cfr 7.1.3)</td>
</tr>
<tr>
<td></td>
<td>Start monitoring data to see potential future market opportunities</td>
</tr>
<tr>
<td>Fluorescent tubes</td>
<td>Separate collection, safe, secure storage</td>
</tr>
<tr>
<td></td>
<td>Send to permitted facilities</td>
</tr>
<tr>
<td></td>
<td>Enable export under fair trade conditions (cfr 7.1.3)</td>
</tr>
<tr>
<td></td>
<td>Start monitoring data to see potential future market opportunities</td>
</tr>
<tr>
<td></td>
<td>Cfr research from technology workshop, collection</td>
</tr>
</tbody>
</table>
6.2.3.1 Goals

Choma’s Master Plan includes the following goals and priorities specifically relevant to Closing the Loop:

**Protection of Human Health**

**T1.1.** Sensitise the public on safety and health issues related to open burning and handling of E-waste: launch first public campaign by the end of the 2nd year of the Master Plan, afterwards ensure continuous awareness raising every year.

**T1.2.** Provide capacity building to workers: training on safe E-waste collection, transportation and storage techniques to be conducted by the end of the 2nd year of the Master Plan, thereafter ensure regular trainings to workers at least once a year.

**T1.3.** Reduce burning occurrences: a burning ban in place by the end of the 3rd year of the Master Plan

By discouraging open air burning, alternative disposal and material extraction solutions can be identified thus increasing overall resource recovery from material previously burned.

**T1.4.** Ensure collection services, certified treatment plants and storage facilities must have hazard preventative measures in place and safe E-waste depollution procedures by the end of the 5th year of the Master Plan

**Conservation of Resources**

**T2.1.** Establish a central storage space for collected E-waste with proper management by the end of the 3rd year of the Master Plan

**T2.2.** Provide collection service (door to door or deposit points) for every zone of the District by the end of the 3rd year of the Master Plan

**T2.4.** Collected E-waste must be checked for re-use and repair first before sending to certified treatment plants by the end of the 4th year of the Master Plan

**Overarching**

**T3.2.** Design an E-waste management system: design paper including financing mechanisms prepared by the end of the 2nd year of the Master Plan

**T3.3.** Fully implement the designed E-waste management system by the end of the 5th year of the Master Plan

**T3.4.** Ensure all collected E-wastes are sent to certified treatment plants by the end of the 7th year of the Master Plan

**T3.5.** Evaluate the performance of the E-waste management system and adjust system design by the end of the 7th year of the Master Plan

**T3.6.** Fully implement the required adaptations according to the adjusted system design of the E-waste management system by the end of the 9th year of the Master Plan

**T3.7.** Ensure the E-waste management system is well functioning by the end of the 10th year of the Master Plan
6.3 Closing the Loop in Kisii

6.3.1 Baseline scenario

Table 3: Baseline Scenario for Kisii, Kenya

<table>
<thead>
<tr>
<th>Name of the County</th>
<th>Kisii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Located in southwestern Kenya between Lake Victoria on the west and South-Western Nau National Reserve on the east approximately 300 km from the Kenyan capital of Nairobi.</td>
</tr>
<tr>
<td>Type of activity</td>
<td>Kisii town is the capital of Kisii county and is the main commercial and urban area in the South Nyanza region. The main economic drivers of Kisii are commerce and agriculture.</td>
</tr>
<tr>
<td>Population's residence</td>
<td>Kisii is densely populated within the urban area with new settlements expanding out from the civic centre.</td>
</tr>
<tr>
<td>Legislation (cfr WP 2.4 for complete details)</td>
<td>Kisii adheres to the national guidelines on waste management, overseen by NEMA. The Environmental Management and Coordination (E-Waste Management) Regulations, including a framework for Extended Producer Responsibility were drafted in 2013 and pending approval at the time of this writing. More information on Kisii’s legislative situation are included in WP 2.4.</td>
</tr>
</tbody>
</table>

Kisii, Kenya, currently offers organic and solid waste collection, which is brought to one waste site. No segregation of waste occurs. In specific context to e-waste management and Closing the Loop for Kisii, Kisii University has reported 7,041 tonnes of e-waste generated per year.

At the moment, there is no approved legislation dedicated to e-waste management, nor financing model adopted at this time however Kenya has ratified the Basel Convention and Amendment, impacts regional upstream and downstream markets. A financial framework to support collection, infrastructure and a takeback system for hazardous material is planned including a budget allocation through Extended Producer Responsibility (EPR).

In the absence of a formal collection system in Kisii, a lot of household e-waste is being stockpiled in homes and backyards thus not entering into a reuse or resource extraction stream. What is collected enters the dumpsites as mixed waste without any segregation done at the source.

In 2015, one commercially owned e-waste collection point was established on Kisii University grounds. The collection point is owned by Nairobi-based dismantling centre East African Compliant Recycling (EACR). With efforts to encourage entrepreneurial initiatives, EACR planned to contract with youth and women groups to collect mixed waste in urban and peri-urban centres and as well collect e-waste which finds its way to electronic and scrap metal dealers for re-use, recycling, resource recovery (for more information on the collection in Kisii, cfr. EWIT WP 2.1). At the time of this report, the collection centre is still
active in Kisii, however activities have halted at EACR. Collected WEEE can potentially be treated by another Nairobi-based dismantling and pre-processing centre, the WEEE Centre.

The competent authorities at national and county levels have a high level of awareness of e-waste risks and potential economic opportunities and public awareness on e-waste management is growing due to specialized courses offered by the University of Kisii as well as the official inauguration of the collection point and the activities of independent collectors however general awareness of Closing the Loop is still relatively low.

6.3.2 Challenges and opportunities
Kisii has made significant progress to introduce comprehensive e-waste management systems with a focus on reducing environmental impact. However, there are still challenges to realize a local closed loop solution. These challenges are described below, followed by specific opportunities available to Kisii.

- CONTAMINATED E-WASTE STREAMS: As detailed in WP2.1 Collection, majority of the e-waste is not collected separately and the e-waste collected, does not get stored separately. If material collected in Kisii will be transported to Nairobi for further dismantling, it is recommended that the material not be baled for transit. Baled mixed e-waste can reduce the eventual resale value of fractions and components due to current market demand of clean streams. Finally, poorly separated material can increase exposure risks to potentially hazardous substances.

- AWARENESS: Awareness on fully integrated e-waste management systems and how to introduce a circular economy is quite low. General public awareness on proper disposal options for e-waste also leads to material resources not being introduced to the secondary materials market.

- REUSE/REPAIR RECOGNITION: In the current waste management guidelines and pending legislation, the value of the local reuse and repair markets may risk exclusion from the waste management stream.

In light of the challenges described, ample opportunities also exist. When the e-waste legislation and financing models are implemented, Kisii will have more resources available to support the collection initiatives defined in the BASELINE assessment. As collection increases, and certain volumes are realized, new commerce can begin in local dismantling and production of secondary raw material.

Kisii University’s program on e-waste management can be leveraged further through internships and externships to drive knowledge, awareness and capacity building in reuse and dismantling activities.

6.3.3 Solutions and strategies
General solutions and strategies for Kisii that can be implemented today include increased awareness, stakeholder engagement and improved collection and separation of WEEE, including sanitary storage solutions for hazardous material.

While awareness of e-waste has become quite high for competent authorities at national and county level, general public awareness is still low. Furthermore, overall knowledge of what circular economy means is low thus linking government, industry, the reuse and repair players present today and academia can start to explore circular economic concepts as applicable to Kisii. Strengthening the link between these important and present stakeholders
in Kisii can also bring new opportunity and synergies as well as help drive awareness initiatives.

Collection should remain a primary focus in the short-term including separate collection and storage of particular waste streams. Enhanced training and sensitization on segregation and sorting schemes will be needed. These first steps will reduce exposure and environmental risks and draw efficiencies in resource recovery and reusability. Training and workers health in the repair facilities should be improved and a logistical flow of obsolete equipment to be delivered to a centralized dismantling and pre-processing facility in Nairobi should be set up. Cfr WP 2.2 Technology for recommendations on how best to treat and prepare flows for transport to treatment facilities.

With one collection point already present in Kisii, collection should remain a priority as well as identify ways to connect the repair and reuse technicians as a stakeholder in the EEE to WEEE value chain. These actions will grow awareness, acknowledge and reinforce the importance of reuse and repair in the value chain. As collection volumes of WEEE increases, local dismantling and industrial collaboration can be explored.

Finally, incorporate data collection points throughout the collection and downstream flows of EEE and WEEE. This will enable Kisii to quantify and qualify downstream local markets for secondary raw material, assess and grow the capacity of these local markets and evaluate the socio-economic performance of these actors against the local brokers. A mid-term review of the collection and treatment results can be reviewed to strengthen the inclusion of e-waste in the waste management plans.

**Table 4: Recommendations per fraction stream for Kisii**

Closing the Loop takes into consideration systematic approaches that can be introduced to as defined above, pragmatic solutions for the key fractions and components have been evaluated given Kisii’s current state of e-waste management.

<table>
<thead>
<tr>
<th>Non-ferrous metals</th>
<th>- National market available.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Implement a data-collection process to gain insights of volumes &amp; flows (surveyed on a product level but not on a material level)</td>
</tr>
<tr>
<td></td>
<td>- Volumes &amp; local demand high enough worth consideration local market development</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ferrous metals</th>
<th>- National market available.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Implement a data-collection process to gain insights of volumes &amp; flows (surveyed on a product level but not on a material level)</td>
</tr>
<tr>
<td></td>
<td>- Volumes &amp; local demand high enough worth consideration local market development</td>
</tr>
</tbody>
</table>

| PCBs               | - Export to Nairobi for pre-processing/depollution & international resource recovery |

<table>
<thead>
<tr>
<th>Hi-tech plastics</th>
<th>- National market available.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Implement a data-collection process to gain insights of volumes</td>
</tr>
<tr>
<td>Category</td>
<td>Instructions</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>&amp; flows (surveyed on a product level but not on a material level)</td>
<td>- Volumes &amp; local demand high enough worth consideration local market development</td>
</tr>
</tbody>
</table>
| BFR plastics | - To fall under EPR proposed financing model  
- Avoid burning or baling  
- Promote local separation by plastic type  
- Explore local market or export when volumes increase  
OR  
- Export to Nairobi for pre-processing & international resource recovery  
- Implement a data-collection process to gain insights of volumes & flows (surveyed on a product level but not on a material level)  
- Start monitoring data to see potential future market opportunities  
- Cfr research from technology and collection workshops |
| CRT / flat panel monitors | - CRT glass: Export to Nairobi for pre-processing & international resource recovery  
- Assess local volumes for investment of CRT cutter  
- Explore artisanal and national options for leaded glass  
- Capacity building on manual dismantling for flat panel monitors, export flat panel displays to Nairobi |
| Batteries (portable) | - Separate collection, safe, secure storage  
- Remove batteries from products brought to collection point and store separately  
- Send to permitted facilities  
- Implement a data-collection process to gain insights of volumes & flows (surveyed on a product level but not on a material level)  
- Start monitoring data to see potential future market opportunities  
- Cfr research from technology and collection workshops |
| Rare-earth | - NA |
| Cartridges / toners | - Upgrade local refilling/refurb activities  
- Identify downstream markets for end-of-life cartridges  
- Implement a data-collection process to gain insights of volumes & flows (surveyed on a product level but not on a material level) |
| Fridge foam | - Separate collection, safe, secure storage  
- Send to permitted facilities  
- Start monitoring data to see potential future market opportunities  
- Cfr research from technology and collection workshops |
| Fluorescent tubes | - Separate collection, safe, secure storage  
- Send to permitted facilities (mobile technology at institutions?)  
- Implement a data-collection process to gain insights of volumes & flows (surveyed on a product level but not on a material level)  
- Start monitoring data to see potential future market opportunities  
- Cfr research from technology and collection workshops |

6.3.3.1 Goals
Kisii’s Master Plan includes the following goals and associated priorities and actions specifically relevant to Closing the Loop:

**Goal 1: Provide effective and efficient e-waste services**

1.1 Expansion of e-waste collection services to the whole market/urban centers in the County.

1.2 Develop an e-waste service delivery plan in all urban areas/rural for collection and establishment of dual bin stations.

**Goal 2: Provide high quality e-waste recovery infrastructure**

2.1 Undertake a feasibility study into the construction of e-waste resource recovery centers.

**Goal 3: Developing regional and strategic partnerships on e-waste management**

3.1 The County to investigate and implement e-waste recycling market strategies and partnerships in the field.

3.2 The County to encourage the re-use/exchange of recyclable e-waste materials and goods.
6.4 Closing the Loop in Johannesburg

6.4.1 Baseline scenario

Table 5: Baseline Scenario for Johannesburg, South Africa

<table>
<thead>
<tr>
<th>Name of the County</th>
<th>Gauteng Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Located in north-eastern South Africa approximately 1500 km from Cape Town and 70km from Pretoria.</td>
</tr>
<tr>
<td>Type of activity</td>
<td>Johannesburg is the provincial capital of Gauteng Province established first by the gold mining industry and now considered the financial hub of South Africa.</td>
</tr>
<tr>
<td>Population's residence</td>
<td>Johannesburg is densely populated within the urban area with many townships including Soweto and Alexandra, falling under the municipality’s jurisdiction.</td>
</tr>
<tr>
<td>Legislation (cfr WP 2.4 for complete details)</td>
<td>Johannesburg adheres to the national policies and legislation on waste management, overseen by NEMA. At this time neither specific legislation nor financing on WEEE exists, it is defined as hazardous waste. Johannesburg has implemented guidelines regulating export of ferrous and non-ferrous waste and a draft of Industry Waste Management Plan was submitted to the Ministry of Environmental Affairs in 2015. More information on Johannesburg’s legislative situation is included in WP 2.4.</td>
</tr>
</tbody>
</table>

Johannesburg is the provincial capital of Gauteng Province with its roots stemming from the gold mining industry and considered the financial capital of South Africa. While South Africa is a coastal country, Johannesburg municipality is landlocked with the closest port approximately 560km away in Durban. Densely populated, with many surrounding townships, the 2012 population estimates were 51.20 million, with a purchasing power of 11,302USD per inhabitant.

Significant investments have been made in its infrastructure, including planned improved fibre connectivity. This will increase demand of IT infrastructure, skills and equipment and the population of Johannesburg is expected to grow. The new industry growth will also anticipate to increase purchasing power of the residents thus also contributing to increased EEE consumption.
In the specific context to e-waste management and Closing the Loop for Johannesburg, the city is making positive strides to identify solutions. In Johannesburg, local industry, academia and government have invested significant time and energy to translate Closing the Loop / circular economy from a theoretical concept to actionable and easy-to-understand discussion. These efforts are paying off now as it is getting more support across levels the levels of the aforementioned stakeholders.

Legislatively, South Africa has a large number of regulations and policies that address waste management and environmental protection as well as the Second Hand Goods Act and the Consumer Protection Act which legally recognizes the reuse markets and consumers of material. WEEE legislation and financing is expected in the near future. South Africa is a signatory of the Basel Convention however has not ratified the Basel Amendment nor are they a signatory to the Bamako Convention. At this time, the high cost of proper disposal is still resulting in WEEE being disposed of through various channels however as the cost of landfilling is increasing, more emphasis on sorting and separate waste treatment for resource extraction is being explored to divert waste from landfills.

At this time, various collection points have been established across Johannesburg to address the growing amounts of e-waste including PikitUp (36), Massmart/Makro (4) and at schools, universities and malls (16). The collection points are seeing positive response however the security at these locations can be increased and a collection solution is currently lacking for communities outside the more densely populated urban environments. More information on the collection opportunities and challenges are outlined in WP 2.1 Collection.

Johannesburg has 7 refurbishers, 16 dismantlers (Tier 3-entry level) and 7 recyclers (Tier 2) however capacity building and volumes are needed to support more Tier 1 recyclers. More information and recommendations can be found in WP 2.2 Technology.
6.4.2 Challenges and opportunities

Johannesburg has made good progress to closing the loop, however significant challenges are still present. In the local context for Johannesburg these interrelated challenges include:

- COLLECTION: While the area around Johannesburg is quite well-developed, most collection services are only offered in the urban area with limited security. This has led to some criminal activities taking place in the urban areas. Additionally, the collection area should be expanded to support e-waste collection services for the neighboring townships and more rural areas are still not able to easily access the collection points. Due to expansive distances, the cost of such collection creates barriers. This, as well as treatment costs, make it difficult to drive proper disposal routes for e-waste.

- MARKET: While Johannesburg has some actors on the ground supporting e-waste dismantling and recycling, more players are needed on the market in order to manage the anticipated e-waste volumes. Additionally, the collection volumes within the municipality need to increase to create economies of scale. As volumes increase, it becomes more economically viable to invest in research and development to identify more extraction and re-manufacturing of resources.

- LEGISLATION/FINANCING: A current blocker to both the collection and economies of scale challenges is the existing provincial jurisdictions and the vast variations of policies from one jurisdiction to another. Furthermore, the current financing model does not support the treatment of hazardous fractions.

- TECHNOLOGIES: Although technologies exist internationally to support optimal resource extraction, those installations are cost prohibitive and require specialized technical acumen to maintain the infrastructure that is not available on the local market. There is a large opportunity to support innovative, locally developed solutions to meet the requirements of the South African markets for e-waste components and fractions.

In light of the challenges described above, numerous opportunities exist that can be developed to further promote and realize a more circular economy. These include:

- The current legislative push and economic impact on landfilling has developed natural incentives for citizens and businesses to seek alternative end-of-life solutions that reduce the amount of material entering into the waste stream.

- Policy makers are in support of closing the loop and reuse. The authorities and industry alike see economic development potential in promoting the circular economy. As such, the government has incorporated investments in R&D in the proposed financing model. Because of this support, new initiatives and incentives like green procurement policies can help reinforce the concept with behavior.

- The market is adept to support circular economic activities as actors are piloting ways to integrate the informal sector into the solution instead of creating competition against the formalized programs. Additionally, Johannesburg has access to established markets to sell back raw materials.
6.4.3 Solutions and strategies

General solutions and strategies for Johannesburg that can be implemented today include introducing incentives that drive purchasing and disposal decisions across the municipality. As investments have been made in infrastructure to support increased resource extraction including yield and volumes, discussions with competent authorities can strengthen stakeholder relation. Potential synergies between the mining industry in the surrounding areas of Johannesburg and academia can be identified to support further R&D in local extraction solutions. Such actions can help drive more conservation of rare earth minerals. Additionally, engaging with the competent authorities to enable cross-province solutions for collection and treatment as well as defining perimeters around controlled, transparent and traceable transboundary movement of WEEE can support local industry run their facilities at maximum efficiency.

In order to support such reliable transboundary solutions, auditing activities towards EHS standards can be introduced and programs to help those active in e-waste management to upgrade their current operations to meet the standards.

Finally, due to the vast distances and rural communities, mobile technologies may be a unique alternative to treat e-waste locally.

Table 6: Recommendations per fraction stream for Johannesburg, South Africa

Closing the Loop takes into consideration systematic approaches that can be introduced to as defined above, pragmatic solutions for the key fractions and components have been evaluated given Johannesburg’s current state of e-waste management.

| Non-ferrous metals | - Technology exists; promote fair trade markets & fair trade considerations  
|                    | - Explore opportunities to upgrade existing technologies (recyclers, dismantlers) |
| Ferrous metals     | - Technology exists; promote fair trade markets & fair trade considerations  
|                    | - Explore opportunities to upgrade existing technologies (recyclers, dismantlers) |
| PCBs               | - Technology in development for local solutions; explore incentives; adherence to internationally recognized standards  
|                    | - Remove logistical import barriers for controlled inflow to reach economies of scale |
| Hi-tech plastics   | - Identify synergies across industry players  
|                    | - Identify opportunities to improve and make more efficient sorting / separation of plastics to meet potential downstream market demand |
| BFR plastics       | - Identify synergies across industry players  
<p>|                    | - Identify opportunities to improve and make more efficient sorting / separation of plastics to meet potential downstream demand |</p>
<table>
<thead>
<tr>
<th><strong>Deliverable</strong></th>
<th><strong>Closing the Loop Operating Guidelines – D 2.3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>market demand</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **CRT / flat panel monitors** | - Increase CRT dismantling capacity with more actors  
- R&D in separation of glass/lead (local market available for lead); solution for powder  
- Future challenge/opportunity: Capacity building and technology on flat panel recycling |
| **Batteries (portable)** | - Awareness campaigns to promote separate collection and storage  
- Remove batteries from products brought to collection point and store separately |
| **Rare-earth** | - Financing models for the extraction process of rare earth in recycling  
- Capacity building around complexity to extract rare earth from e-waste |
| **Cartridges/toners** | - Develop / introduce technology for recycling cartridges  
- Create legislation to get producers commitment |
| **Fridge foam** | - Awareness on proper disposal; collection and logistics from rural areas; remove doors before disposal  
- Facilitate discussions of stakeholders to develop climate for investment and economies of scale to develop local treatment technology and options |
| **Fluorescent tubes** | - Awareness on proper disposal, EPR, access to collection points |

**6.4.3.1 Goals**

Johannesburg’s Master Plan includes the following goals and priorities specifically relevant to Closing the Loop:

- Strengthening the collection systems, transportation, storage and disposal of e-waste. Pikitup will facilitate the collection of e-waste and other recyclable waste streams through initiatives such as bulk e-waste collections from households and corporate entities and provision of storage facilities for such waste.

- Increase separation of waste into recyclable and non-recyclables at source. Households should be encouraged to separate recyclable e-waste products such as lighting, consumer electronics, information and communication technology products from other household and garden waste streams that are non-recyclable.
- Increasing household awareness on e-waste consumption, waste minimization, recycling and disposal to encourage behavior change and grow e-waste collection volumes.

- Development of a better e-waste data management system to understand the origins, pathways, immediate and final sinks of e-waste materials along the value chain. This will be helpful in determining the interventions that are required in capturing the flows of e-waste materials from generators to waste management facilities such as buy back centres, material recovery facilities (MRFs) and landfills within the city and neighbouring metropolitan cities.

- Upgrade the provision of security at garden sites to enable secure collection and storage of e-waste materials at garden sites.

- Development and strengthening of partnerships between the City of Johannesburg, higher learning institutions and neighbouring cities to share knowledge on e-waste management and achieve economies of scale.

### 6.5 Closing the Loop in Abidjan

#### 6.5.1 Baseline scenario

**Table 7: Baseline Scenario for Abidjan, Ivory Coast**

<table>
<thead>
<tr>
<th>Name of the District</th>
<th>Abidjan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Located along the coast of Gulf of Guinea and the south Atlantic Ocean, in the south-eastern part of Ivory Coast on the Ébrié Lagoon covering 0.7% of the national surface area with 2.120 km$^2$. Abidjan benefits from 2000 km of bituminized or unbituminized road.</td>
</tr>
<tr>
<td>Type of activity</td>
<td>Abidjan is the economic capital of Ivory Coast</td>
</tr>
<tr>
<td>Population's residence</td>
<td>The population of Abidjan is 5.5 million inhabitants, making up 21% of the national population. Some 4.4 million people live in the city whereas only 320 thousand are in rural areas corresponding to 2.594 inhabitants per Km$^2$. With an urban development rate of 95%, Abidjan is the main city in the Abidjan District where around 80% of the national economic activities are conducted.</td>
</tr>
<tr>
<td>Legislation (cfr WP 2.4 for complete details)</td>
<td>Abidjan is in the process of developing their national waste action plan and strategy to be implemented between 2016 and 2020. It is currently pending final approval. The Ivorian state is responsible for the legislative framework, to be implemented by the private sector and monitored by the Ministry of Environment.</td>
</tr>
</tbody>
</table>

In specific context to e-waste management and Closing the Loop for Abidjan, the need for adequate e-waste is a recognized issue at the legislative level and is anticipated to drive towards local and global circular economy.
Estimates from 2011 suggest a generation of 15,000 tonnes per year of WEEE but this is expected to be a clear underestimate, based only on measurements at two recycling associations.

There is no legislation dedicated to e-waste management, nor financing model introduced at this time however Ivory Coast has ratified the Basel Convention and the Bamako Convention which may have a future impact on upstream and downstream markets and the import of hazardous material, as defined by the Basel Convention is illegal. EEE/WEEE collection and the reuse/repair activities are informally managed through individual actors and has a strong presence in the local economy. However no incentives nor system is in place to collect, store or treat non-valuable or hazardous e-waste material.

WEEE collectors, which may include children, have organized themselves into an association and are now registered with the Ministry of Environment. This allows the association to receive recognition by the Ministry as a stakeholder in matters related to WEEE management in Ivory Coast, including a spokesperson who participates in stakeholder dialogues. The only registered association in Ivory Coast to date (Dec. 2015) is in Abidjan. In contrast, these collector associations are not recognized by the municipality.

The collectors sell their wares to various repair shops situated in large refurbishment markets. These markets are also organized as an association with a president who represents the interests of the repair shops in stakeholder engagements. Each repair technician rents space from the association and is individually registered with the municipality as a tradesman with a registration number and pays taxes. At this time, these reuse shops are not recognized by the Ministry of Environment. There is no large presence of any further recycling or resource extraction activities after reuse and repair.

Certain fractions, including scrap material that cannot be refurbished is sold from the repair/reuse shops to brokers. Here the flow of material becomes less clear as there is no registry of available brokers or publicly agreed upon rates for goods. Most relationships are through personal connections. There can be many intermediaries in this system based on available resources. The first-tier intermediary may buy scrap and has a truck to facilitate transport and a small storage site. As volumes grow, the scrap will often be sold to a second tier intermediary with a larger storage facility. These large volumes are sold and exported to Ghana via road transport, often with limited documentation.

Occasionally, if the price offered by a first-tier intermediary is not attractive for the shop owners, the shop owners will combine their stock to fill a container and deal directly with an exporter. This is a volume transaction, access/cost for vehicles to move freight and storage/stock-piling capacity. If stores combine stock, the revenue of the container is divided based on the % of weight their stock contributed indicating no differentiation on the value variation of waste.

Various entrepreneurial activities for EEE/WEEE upcycling are present in Abidjan but stakeholder awareness of the potential risks of using WEEE fractions in other forms is low. One example provided during the workshop was the upcycling of EEE plastics into reusable food containers. The market for this product is slowly increasing, and has a potential impact on waste reduction of other streams, however the impact to human health in using recycled EEE plastics, particularly BFRs was not assessed.

6.5.2 Challenges and opportunities
Abidjan has number of challenges as well as opportunities present to explore when closing the loop for e-waste.
- LEGISLATION / REGULATION: At the time of this publication, Abidjan’s e-waste legislation was still pending thus the consortium members were unable to assess the potential legislative measures proposed that can support or hinder circular economic activities. Without legislation, a financing model and a regulatory framework, it is challenging to enforce any existing environmental protection measures currently taken by the municipality of Abidjan and by the Ministry of Environment. This includes the limited capability to control illegal dumping and enforce the international agreements. Illegal dumping leads to environmental risks as well as the potential loss of valuable secondary raw material. Furthermore, when the international agreements are not fully understood or respected, more material can be imported into the country without the proper facilities to treat it and the value chain of secondary raw material does not get equally distributed having an economic impact on the municipality and the reuse/recycling sectors.

- INFRASTRUCTURE/FINANCING: Majority of the secondary EEE and WEEE industry is managed through the informal sector lacking skills and tools to drive optimal resource efficiency primarily on asset reusability. Additionally, no e-waste recycling activities exist today to support keeping secondary raw material within the local economy. Financing is necessary to support the collection and proper treatment of all fractions from e-waste and capacity building to professionalize the EEE and WEEE collection and introduce some basic material recycling under conditions that respect environmental health and safety standards and activities that can promote further resource extraction.

- QUALITY AND LIFE OF PUT ON MARKET MATERIAL: Closing the loop, based on circular economic concepts is restorative by design. Thus there should be an aim to keep products, components and materials at their highest utility at all times (EWASA). The quality and lifespan of new products introduced to the Abidjan market was identified as a challenge for the reuse, repair and recycling sector. If PoM is low quality or has a short lifespan, devices move through the product lifecycle at a higher frequency and if the quality of the components are low, reparability and reuse is diminished. If the material contains high volumes of hazardous substances, the final extraction processes or disposal can have environmental consequences.

- DATA COLLECTION: In order to prioritize actions to close the loop on EEE, more information is needed EEE PoM, material flows and volumes. This data collection can be built into voluntary pilot projects (collection, capacity building, manual dismantling, etc). As material comes into a collection point or repair shop, the assets can be documented by type, make, model and source. As material transfers ownership down the value chain, the collection point or repair shop can document the downstream vendor, weights, etc.

- PROPER COLLECTION AND DISPOSAL OF HAZARDOUS MATERIAL: At the time of this report, common disposal practices of municipal waste include general disposal at the dumpsite or in the lagoon and burning. Furthermore, the absence within any current or planned legislation or regulation on proper collect, store or dispose of hazardous material from WEEE was discussed. No system is in place to collect liquids (e.g. oils, refrigerants, etc.). Dismantling of components is often done directly on the soil or in improvised structures. This creates an environmental risk.
In light of the aforementioned challenges, Abidjan also demonstrates a lot of opportunity to close the loop locally by leveraging the strong base that exists today. Repair and reuse is very strong in the Abidjan culture, thus a dynamic collection system exists today to bring non-working and under-used EEE back into a productive state.

The entrepreneurial activities have already demonstrated potential solutions and local markets for metals and plastics. The casting aluminium that is recovered has been used to make parts for gas stoves. Such activities can continue to be encouraged, coupled with capacity building to avoid potential exposure risks during processing and use phase.

At the national level, there is a growing interest in e-waste and many ministries are involved in the discussion, garnering more support to find solutions for e-waste management and circular economy. The country has already ratified the Basel Convention and Bamako Convention. The level of stakeholder engagement, including formal representation of the EEE/WEEE collectors and repair technicians, has aided in open debates and discussions on the topic and been instrumental in the drafting of the pending e-waste legislation.

6.5.3 Solutions and strategies

General solutions and strategies for Abidjan that can be implemented today include capacity building, encouraging and incentivizing new production models from secondary raw material and identifying solutions for hazardous material.

Abidjan has a strong foothold in the collection, reuse and repair phase of the circular economy and can build upon this existing industry by introducing protective equipment, better training and knowledge transfer across the repair sector and some tools that will assist in increasing efficiency and minimizing EHS risks. In addition to the technology recommendations provided in WP 2.2, these do follow:

- Upscale the informal sector with better tools, equipment and training
- Protective equipment
- Infrastructure development
- Skills transfer
- Encourage use of secondary material
- Solutions for the hazardous materials needed

Table 8: Recommendations per fraction stream for Abidjan

Closing the Loop takes into consideration systematic approaches that can be introduced to as defined above, pragmatic solutions for the key fractions and components have been evaluated given Abidjan’s current state of e-waste management.

<table>
<thead>
<tr>
<th>Non-ferrous metals</th>
<th>- Local market exists, improve the upcycling process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous metals</td>
<td>- Local market exists, improve the upcycling process</td>
</tr>
<tr>
<td>PCBs</td>
<td>- Implement system for compliance with legal mechanisms for export</td>
</tr>
<tr>
<td></td>
<td>- Review application of export permits within ECOWAS region to promote regional solutions &amp; economies of scale</td>
</tr>
<tr>
<td></td>
<td>- Recommendations on controlled TBM within ECOWAS</td>
</tr>
<tr>
<td>Category</td>
<td>Recommendations</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Hi-tech plastics</td>
<td>- Explore upcycling opportunities</td>
</tr>
<tr>
<td></td>
<td>- Work with universities on potential exposure risks of current upcycling solutions</td>
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<tr>
<td></td>
<td>- Application of other plastics recycling</td>
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<tr>
<td></td>
<td>- Recommendation of possible/suitable other production streams for plastics (non-food container)</td>
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<tr>
<td>BFR plastics</td>
<td>- Avoid burning</td>
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<tr>
<td></td>
<td>- Explore opportunities for upcycling</td>
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<tr>
<td></td>
<td>- Include under a financing model for takeback and proper storage/export</td>
</tr>
<tr>
<td>CRT / flat panel monitors</td>
<td>- Include under a financing model for takeback and proper storage/export</td>
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<tr>
<td></td>
<td>- Explore opportunity to introduce appropriate dismantling technologies</td>
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<td></td>
<td>- Explore regional solution</td>
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<tr>
<td></td>
<td>- Awareness on proper dismantling for flat panels and risk of exposure</td>
</tr>
<tr>
<td>Batteries (portable)</td>
<td>- Include under a financing model for takeback and proper storage/export</td>
</tr>
<tr>
<td></td>
<td>- Separate collection, safe, secure storage</td>
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<tr>
<td></td>
<td>- Remove batteries from products brought to collection point and store separately</td>
</tr>
<tr>
<td></td>
<td>- Send to permitted facilities (export)</td>
</tr>
<tr>
<td></td>
<td>- Start monitoring data to see potential future market opportunities, cfr research from technology workshop</td>
</tr>
<tr>
<td>cartridges</td>
<td>- Upgrade the refilling/refurb activities</td>
</tr>
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<td></td>
<td>- Identify downstream markets for end-of-life cartridges</td>
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<tr>
<td>Fridge foam</td>
<td>- Explore reuse</td>
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<tr>
<td></td>
<td>- Explore regional downstream options (Nigeria)</td>
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<td></td>
<td>- Remove doors before disposal</td>
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<tr>
<td>Florescent tubes</td>
<td>- Separate collection, safe, secure storage</td>
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<tr>
<td></td>
<td>Send to permitted facilities (mobile technology at institutions?)</td>
</tr>
<tr>
<td></td>
<td>Start monitoring data to see potential future market opportunities, cfr research from technology workshop</td>
</tr>
</tbody>
</table>

6.5.3.1 Goals
Abidjan’s Master Plan includes the following goals and priorities specifically relevant to Closing the Loop:

- Formalise the e-waste sector, including the reuse and repair industry already present in the district
- Provide more reliable and reliable statistics on e-waste
- Increase the collection rate of e-waste
- Sensitise the population on e-waste issues
- Increase the local recycling capacity
- Have a specific legal framework on E-waste management

Furthermore Abidjan’s Master Plan identified the following objectives which are relevant to Closing the Loop:

- Provide training to the workers of informal sector
- Raise awareness on the toxicity of e-waste when disposed incorrectly in the environment and by households
- Set an effective collection system and increase the collection rate
- Facilitate the creation of recovery centres to create more social and economic values locally
- Create a local market for secondary raw materials
- Divert E-waste from public landfills
- Drive accountability and incentives to collect all e-waste fractions
- Implementation of best practices including flexible policies allowing them to change as technology develops

7 Part 2
7.1 Introduction: shared solutions for common challenges

Identifying common challenges to Closing the Loop across the four analyzed scenarios in Africa was not too difficult as many face similar challenges to introduce circular economic solutions, as is also experienced in other parts of the world.

The following issues: collection, technology, legislation on e-waste, enforcement of e-waste legislation, awareness activities, access to market, and functioning financing model were reoccurring themes in all four of the scenarios when analyzed under the specific challenges for Closing the Loop. Some of these themes have been analyzed elsewhere within EWIT but not with a closing the loop lens. Thus in order to analyze these scenarios for the purposes of this deliverable, each point was rated on a scale from 0 to 5, 0 being non-existent and 5 being fully advanced.
7.2 To know about Closing the Loop

It is important to note that to truly obtain a circular economy, further elements of the supply chain and value chain need to be addressed. For the purpose of EWIT and the Expert Modeling Workshop on Closing the Loop, the recommendations have been limited to the product lifecycle from consumption to end of life.

After agreeing upon the factors and their gradual ranking, the municipalities were given a ranking taking into consideration only the current situation, not drawing conclusions of how a situation may change after implementation of planned actions such as e-waste directed legislation or a financing model. It is important to note that the scenario analyzed each municipality against the other three municipalities thus not an overall ranking of where they fall against a utopic situation.

The progression from 0-5, as defined below, can also be viewed as incremental growth and development KPIs to realizing more closing the loop solutions for e-waste management bearing in mind this does not include other elements of circular economic thinking like product design and reuse of secondary raw materials.
Table 9: Common challenges for Closing the Loop solutions

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collection</td>
<td>none</td>
<td>manual collection, informal</td>
<td>Separated storage &amp; collection in appropriate containers</td>
<td>Household / enterprise collection connected to repair / reuse markets / collection to waste stream</td>
<td>Separate collection &amp; storage; data collection (volumes; sources)</td>
<td>Organised waste management system; linked to reuse markets; quantity traced; data available</td>
</tr>
<tr>
<td>2. Technology</td>
<td>none</td>
<td>manual dismantling; no PPEs; very basic tools; no technology in collection</td>
<td>collection technology; manual dismantling; PPEs; starter toolkit</td>
<td>manual dismantling; PPEs; consistent access to electricity; pre-processing equipment (cfr WP 2.2 Technology - minimum collection thresholds)</td>
<td>Manual dismantling; consistent access to electricity; pre-processing equipment; skilled workforce; internationally recognized certifications (ISO14001; OHSAS 18001)</td>
<td>high-level industrial facility; skilled/trained workforce; data available</td>
</tr>
<tr>
<td>3. Legislation on e-waste</td>
<td>no legislation on waste / on e-waste</td>
<td>basic national legislation on waste; no specific legislation on e-waste</td>
<td>National level e-waste legislation; National authority recognized</td>
<td>Municipal level legislation on e-waste; municipal authority recognized</td>
<td>Municipal level legislation on e-waste; municipal authority recognized; registered approved service providers</td>
<td>legislation covering e-waste, in line with the directives…; data available</td>
</tr>
<tr>
<td>4. Enforcement of e-waste leg.</td>
<td>No law to enforce</td>
<td>law not enforced</td>
<td>very poor enforcement</td>
<td>basic enforcement; resource available</td>
<td>Intermediate enforcement; competent authority and resources available</td>
<td>high-level enforcement; data available</td>
</tr>
<tr>
<td>5. Functioning financing model</td>
<td>no financing</td>
<td>none to very poor financing</td>
<td>Defined party responsible, Basic financing available, competent authority</td>
<td>Intermediate financing w/ transparency</td>
<td>Intermediate financing w/ transparency managed by competent authority</td>
<td>extensive financing model; data available</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>6. Awareness activity</td>
<td>No awareness or need for awareness</td>
<td>Recognized need for awareness, no current awareness activity</td>
<td>very low awareness activity</td>
<td>Authority awareness, public awareness low</td>
<td>Authority awareness high; public awareness high</td>
<td>extensive awareness campaign at national and local level; data available</td>
</tr>
<tr>
<td>7. Access to Market</td>
<td>no access to the market</td>
<td>Reuse/repair sector; access to restricted local/captive market complete product; price out of control</td>
<td>Reuse/repair local/national market; access to national/international market for component/fraction streams; logistical blockers; price blockers</td>
<td>access to transparent, certified national/international market for some streams; no logistical or price blockers</td>
<td>access to transparent, certified national/international market for all streams; no logistical price or blockers</td>
<td>access to transparent, certified extended/glocal market; quantity traced; data available; reintroduction to new production</td>
</tr>
<tr>
<td>8. Collection and treatment of hazardous material*</td>
<td>No system in place to collect and treat hazardous material</td>
<td>Basic collection in general waste and e-waste activities. No segregation at collection or storage</td>
<td>Separate collection but no proper storage or treatment available at local level, possible storage/treatment available nationally</td>
<td>Separate collection and storage or treatment available at local or national level, no secondary use market available</td>
<td>Separate collection and storage or treatment available at local or national level, some secondary use market available for particular fractions but not for all</td>
<td>EHS standards recognized secondary markets available thus creating no additional waste</td>
</tr>
</tbody>
</table>
8 Part 3

8.1 Considerations to support policy makers in Closing the Loop

Further details on the factors to consider when introducing closing the loop solutions are defined below for consideration by policy makers and relevant stakeholders, particularly guidelines for collection and treatment on hazardous material, technology, legislation and finance, access to secondary markets and considerations for transboundary movement.

8.1.1 Collection & treatment of Hazardous material - Considerations for Closing the Loop

In addition to the roadmap above, and the recommendations found in EWIT Collection Operating Guidelines, further details are included here on potential proper collection and separation of hazardous e-waste material.

8.1.1.1 Hazardous Waste - the Waste Hierarchy

It is important to recognise that the preferred solutions for dealing with potentially hazardous materials and components found in e-waste follow the same hierarchy of priorities as for other wastes.
That is to say: wherever possible, suitable options for prevention - e.g. through using rechargeable not disposable batteries - and re-use – e.g. through repairing unwanted products - whilst keeping the components in good working order are the safest and most environmentally sound means of managing hazardous e-waste components, and these should remain the priority.

The primacy of applying the waste hierarchy for hazardous components in e-waste reinforces the need for effective education and awareness targeted at users and producers of e-waste to avoid the generation of hazardous e-waste in the first place.

By keeping EEE in good working order any materials which may be inherently hazardous are also likely to remain in a safe condition with little or no exposure to the hazards. It is only when products are broken, or reach the end of their life, that significant increases in exposure start to occur whilst implementing options which are lower down the waste hierarchy.

8.1.1.2 Recycling Hazardous Items

Recycling e-waste – i.e. the disassembly of products and separation of materials for the purposes of recovering materials from e-waste whilst accepting the loss of functionality of the component/product – should be viewed as being different from re-use and repair of items. Recycling of e-waste, including hazardous e-waste, should therefore be reserved for items that no longer function and have truly reached their ‘end of life’.

E-waste recycling of hazardous material in accordance with the above definition, involves processes that can present significant risks in themselves e.g. acid leaching of metals from printed circuit boards. It is vital, therefore, that such activities are carried out with appropriate technologies by staff with suitable skills and protective equipment.

Readers should refer to the EWIT ‘Technology’ Operating Guidelines report for a full description of suitable e-waste recycling approaches and equipment. Following these guidelines will ensure the hazardous e-waste items are suitably managed.
In many cases it may be necessary to export hazardous e-waste items in order to access suitable facilities with the required technology. This can be complicated and require the necessary financial and regulatory arrangements to be in place, but will often be required if long-term issues associated with inappropriate management of hazardous e-wastes are to be avoided nationally.

8.1.1.3 Hazardous E-Waste that cannot be Recycled
Situations may occur where it is not immediately practicable to recycle hazardous E-waste items. Such situations may arise for the following reasons, for example:

- Lack of suitable facilities locally/nationally to treat hazardous items;
- Insufficient quantity to warrant transport to a treatment facility;
- Hazardous items which have negative value and there is insufficient funding to pay for treatment; and
- Market/regulatory barriers which can frustrate attempts to access treatment facilities, particularly if export is the only option.

Hazardous e-waste items that cannot be re-used or recycled should be managed in a responsible manner. It should be recognised that the treatment of hazardous e-waste is a highly specialist industry that requires very high levels of environmental controls to be in place if it is to avoid significant pollution further down the line. Its treatment (or disposal) should not therefore be undertaken in an ad-hoc manner without the proper controls being in place. Government has a significant role to play in fostering, developing and regulating such an industry as a critical part of national infrastructure. Nonetheless, in many nations this infrastructure is not currently developed and the management of hazardous e-waste can be problematic, at least in the short term.

8.1.1.4 Temporary Storage
Storage is a temporary holding of the wastes while arrangements are put in place for its proper treatment or disposal. It is not a solution for waste to be stockpiled with no long-term solution, as this has the potential to cause environmental harm to the site and represents a significant financial liability for the holder. However, prior to appropriate facilities becoming accessible temporary storage might sometimes be necessary, and may be preferable to the uncontrolled dumping of the waste.

There are two main types of storage: on-site and off-site. On-site storage is within the premises of the waste generator – which for e-waste could be at the site of partial disassembly where certain components cannot be treated - while off-site storage removes the wastes from the premises on which they were generated to be kept centrally, as part of planned larger waste management system. Both types of storage are pending the treatment or disposal of the wastes.

Storage should be for as brief a period as possible, whether it be on or off-site, and suitable storage locations with appropriate containers should be used. The most important provisions to ensure this include:

- the appropriate physical design of the storage area;
- the correct labelling of the waste containers;
- clear signage for the storage area;
- appropriate duration of storage; and
- Employee training.
Guidance regarding site infrastructure and suitable containers is provided in the EWIT Operating Guidelines for ‘Collection’.

8.1.1.5 Thermal Treatment

The uncontrolled combustion of any e-waste item should be avoided. This is acutely important with regards to hazardous e-waste, as the environmental and health risks posed by inappropriate combustion can be severe. Consequently, unless thermal treatment can be conducted by dedicated treatment plant, with proper and regulated emissions control systems then it should not be considered as an option for e-waste.

Thermal treatment in general is only suitable for ‘organic’ materials e.g. plastics from e-waste housings, and is not suitable for many other types of e-waste e.g. metals. Consequently, thermal treatment is only suitable for e-waste that has been processed, disassembled and has had the inorganic contaminants (e.g. metals) removed for recycling in other ways.

Such e-waste material can be treated in dedicated high temperature hazardous waste incineration facilities, and this could be an option for certain types of e-waste plastics, including those containing Brominated Flame Retardants (BFRs), or oils containing PCBs which can be found in some older industrial power transformers. These facilities typically operate at temperatures of 1,150 °C or higher and have advanced flue gas treatment systems. However, such facilities are highly specialised and comparatively few in number around the world. Consequently, it is likely that many countries will not have access to such facilities in-country. The costs of such treatment are high, and the export of such materials to facilities elsewhere is tightly regulated under the Basel Convention.

It is also possible, however, for some industrial processes which use wastes as fuel, and it is conceivable that these could be suitable for certain types of e-waste. These include industries such as steel, glass and cement manufacture, but of these, cement kiln use is the most likely. Many countries will have a national infrastructure of cement kilns and the use a cement kiln for the thermal treatment of certain hazardous organic wastes can be technically and environmentally sound.

Cement kilns have been used extensively for many years for hazardous wastes treatment. As cement production is very energy intensive (40-65% of total cost), the saving in primary fuels makes the burning of organic wastes attractive from the kiln operator’s point of view. The typical combustion conditions include temperatures in the range 1,350-1,650°C so that complete destruction of organic pollutants is assured.

It is important to realise that any industrial user of e-waste as a fuel will not be able to use ‘raw’ e-waste. It has already been stated that only e-waste that has undergone some form of pre-processing to remove inorganic contaminated material would be potentially suitable. However, it is almost certain that the material will have to be further processed to a consistent Solid Recovered Fuel (SRF). The compatibility of SRF in cement kilns is governed by several factors, such as thresholds for key inorganic contaminants like Chlorine and metals such as Cadmium, and these would have to be demonstrated as being complied with before an industrial operator would consider its acceptance.

The use of SRF by industrial users has been studied in detail and standards have been suggested for key properties to establish a common understanding on its suitability for different end-users. Detailed information has been published by the European Committee for Standardisation in: Key Properties on Solid Recovered Fuels to Be Used for Establishing a Classification System; CEN/ TS 15508:2006, which provides a useful reference.
The thermal recovery of certain hazardous e-waste fractions is therefore technically feasible in some cases. However, it is a highly technical field which requires experienced operators in order to effectively control the risks. Such conditions are likely only to be satisfied in mature industries which have the analytical and operational controls in place to implement it safely, and will certainly be high profile infrastructure operators with a national or international profile. If a thermal facility does not conform with this highly developed profile it is unlikely that it represents a justifiable outlet for hazardous e-waste.

8.1.1.6 Landfill
Landfills form part of every integrated waste management system. However, only properly engineered and operated landfills provide adequate levels of pollution control and this is especially true with respect to the disposal of hazardous E-wastes. The disposal of hazardous E-waste in uncontrolled dumpsites is not acceptable.

The landfilling of hazardous waste items, of any sort, has significant environmental risks. Research into such landfills and high profile examples of the health effects on populations living close to such sites has raised the issue to one that is considered on an international level. The United Nations Environment Programme (UNEP) in conjunction with the International Solid Waste Association (ISWA) have attempted to provide guidance on the establishment of suitable facilities with their Training Resource Pack for hazardous waste management in developing countries (UNEP, N.D.)

Landfilling hazardous materials is a very specialist operation – this puts it beyond the typical organisation whose ‘core business’ is simply the management of e-waste. If performed in a responsible manner it requires significant engineered infrastructure and financial provisions to be in place for the very long term storage of such wastes. Again, if these requirements have been created and fulfilled, these are likely to be high-profile sites of national importance within the waste industry for any country. Any other approach is likely to cause severe problems down the line.

In the absence of specific hazardous waste landfills, some ‘transitional’ technologies may be suitable in the short-term for some areas, for some wastes. The concept of transitional technologies is that they are a ‘stepping stone’ on the way to the evolution of a state-of-the-art system for waste minimisation, recycling treatment and disposal. These transitional technologies may include: co-disposal of selected waste with domestic wastes in properly controlled municipal solid waste landfill sites; and cement waste solidification at a landfill site. Again, this is a highly complex issue that requires consideration of specific circumstances and the UNEP/ISWA report (above) provides some guidance on these issues.

From an e-waste management perspective at a local level, if the infrastructure described above is not in place and operated by a robust and well-regulated organisation then landfilling of non-recyclable hazardous e-waste should be avoided. If wastes have no immediately accessible outlet then temporary storage of the hazardous items must be considered to facilitate the later identification and implementation of suitable outlets for the material.

8.1.2 Technology Considerations for Closing the Loop
As appropriate technologies for the dismantling and pre-treatment of all six targeted product categories (small IT and telecommunication equipment, small equipment, large equipment, temperature exchange equipment, screens and monitors, lamps) have been already
extensively been covered in “D2.2 Technology Operating Guidelines”, this section will only highlight technological options and considerations to close the loop in promotion of a circular economic model for valuable and hazardous fractions coming out of the described dismantling and pre-treatment processes.

The biggest fraction coming out of manual dismantling are several metals (e.g. iron and aluminium from housings, copper after stripping cables, …) and plastics. For those materials normally at least one buyer can be found on the national market. In order to sell them for a good price it is essential to obey the international quality standards for the respective output fraction.

Special attention should be paid to normally rather complex material mixes (e.g. printed circuit boards, …) containing a high concentration of precious (e.g. gold, silver, palladium, …) and critical metals (e.g. rare earth, platinum, …). For those only a small number of specialized precious metal refineries can be found worldwide (e.g. Aurubis in Germany, Boliden in Sweden, Umicore in Belgium, …). Besides them smaller companies are currently coming on the market using pyrometallurgical (e.g. Attero in India, …) as well as hydrometallurgical processes (e.g. HydroWEEE who even offer a mobile solution).

Last but not least a very important fraction with a big environmental impact are hazardous components and substances (Lead-glass from CRTs; Batteries and accumulators containing any of these: Li-Ion, NiMH, NiCd, Lead-acid; Printer cartridges (typically not hazardous but considered amber listed under Basel convention when no material safety data sheet can be provided for each and every different type of cartridge); BFR plastics (plastics containing Brominated flame retardants); Mercury containing lamps, switches, relays; Transformers, capacitors, switches containing polychlorinated biphenyls (PCBs); CFCs, HCFCs, oils from fridges, freezers, air conditioners). For most of these fractions no national solution might be available at the beginning. As these components and substances are hazardous either a proper storage solution has to be found until a national (maybe regional) solution has been built up or controlled export under the Basel Convention to already existing treatment facilities in other countries has to be allowed.

For all technologies mentioned before “economy of scale” is really important to ensure a proper and profitable operation. As normally it takes some time to reach sufficient volumes in a country that is starting to set up a proper e-waste management system, potential solutions for such a transition period can be:

- Looking for synergies with national mineral processing sector (e.g. for precious metals)
- Allowing controlled export (e.g. of hazardous components)
- Using mobile technologies (e.g. mobile fridge treatment plants, mobile HydroWEEE plant for printed circuit boards, powder from fluorescent lamps and CRTs, batteries, LCDs, …)
- Regional specialisation / treatment networks: one country specializes on the treatment of one hazardous substance and another one on another one. And then a controlled, regional exchange of material takes place in order to reach together the necessary economy of scale.
All these measures should be complemented with research and development activities for local, low cost and low volume (maybe mobile) treatment technologies that will also create additional jobs in the country.

This will also soften the problems with training and maintenance that normally occur with imported high-tech plants.

8.1.3 Legislation & Financing Considerations for Closing the Loop

As an expansion to the findings in EWIT Operating Guidelines “Legislation and Financing” additional recommendations have been taken here for consideration to support Closing the Loop solutions at the municipal and national level. This list is not exhaustive, additional solutions can be considered as new models of circular economy are arising globally.

Some actions that can be introduced legislatively include:

- Encourage green procurement policies. This can include targets around average product life, purchasing remanufactured products or products made of recycled material.

- Collaborating on other green economic initiatives being introduced into the country for instance in Kenya, the draft Green Economy Strategy and Implementation Plan (GESIP) was introduced in 2015. Closing the Loop falls strongly under the Strategic Area 4 on Promoting Resource Efficiency.

- Incentivise repair and remanufacturing through tax breaks.

- Encourage producer take-back, as a customer offering in-stores for via delivery/pick up services.

- Set targets not just for recycling but also for reuse.

As the collection and proper treatment of hazardous e-waste falls under any closed loop solution, policy makers should also recognize that financing is necessary to provide such services. As already discussed in 7.1.1, the treatment of hazardous e-waste is a highly specialist industry that requires very high levels of environmental controls to be in place if it is to avoid significant pollution further down the line. Its treatment (or disposal) should not therefore be undertaken in an ad-hoc manner without the proper controls being in place. Government has a significant role to play in fostering, developing and regulating such an industry as a critical part of national infrastructure.

8.1.4 Access to Secondary Markets Closing the Loop Considerations

Summary success factors for access to secondary markets

The following success factors for market access for secondary markets with focus on Africa can be summarised as:

- INFORMATION: On what is needed, in what quality, price information, who are the buyers, what is the administrative/legal process, what is sound environmental management, technologies to allow upgrading, health and safety, future trends and regulations. Information flow along the supply chain should be encouraged.
- **NETWORKS**: to access information, material and buyers

- **HUBS**: Need to be able to pool material locally, e.g. via cooperatives and middlemen, and regionally (including transboundary transport) to provide sufficient volumes to operate at scale.

- **POLICIES & LEGISLATION**: Needs to be aligned to economic incentives in the market and give all partners confidence in investing in and doing business with certain locations and partners. Need for transparency and accessibility to information regarding as to who is a legal entity, who can sell or transport material and what are correct formalities. Incentives must exist for all participants in recycling to cooperate with the other participants for improving the system’s recycling performance. Focus needs to be on whole supply chain, not on individual actors or aspects - inter-dependencies need to be recognised

- **CERTIFICATION & BEST AVAILABLE TECHNOLOGY**: to improve quantity, quality and type of material made available and increase profitability

- **LEVEL PLAYING FIELD**: Setting and enforcement of standards – cutting corners should not lead to better profits.

- **DEMAND - SUPPLY**: Price of secondary material is coupled with price of primary material and global price fluctuation increases the risk for (particular small) recyclers and gives an unstable economic footing. Need for good understanding of the market and future trends

- **INFRASTRUCTURE / SERVICES**: access to credits and loans, information and transportation

- **REMTENESS**: Limits networks, information, makes hubs more difficult, less access to infrastructure and services

**Background**

While there is a rich body of literature on e-waste, both in scientific journal papers as well as studies and reports, there are only few that address the access to market topic directly. Some relevant publications, which touch directly or indirectly on the topic are summarised here.

**From a recycling point of view**

The very detailed UNEP study on metal recycling (2013) describes key aspects that are relevant to improve recycling. Aspects which are also of relevance for market access are:

- Best available technology (BAT) by certified authority raises overall level of recycling
- Policy and legislation need to align with economic incentives
- Level playfield – internalisation of external costs
- Collection of post-consumer waste is often a logistically challenge – a major actuator being the minimisation of costs, rather than the maximisation of material efficiency
- Well organised collection and per-processing systems are often missing
- The need for transboundary transport to facilitate the generation of hubs to ensure sufficient volumes of secondary materials are available for treatment
Further, the study argues that the influencing the economics of any part of the recycling chain will be changing the economic viability of the whole chain or of any part of it. Providing the incentives and means for stakeholders in the recycling chain to exchange information and cooperate to increase recycling. Set framework conditions that enhance recycling, such as setting certified standards are important. Rather than looking primarily at recycling rates, policy could much more usefully focus on creating a robust BAT platform for recovering metals and helping industry to do this. A BAT infrastructure, once in place, will operate by itself to maximize the recovery of all valuable elements with an economic incentive to do this.

The Handbook of recycling (2014) discusses the following key factors in context of market access:

- How much of this material is available for recycling? What is the potential to extract from waste products?
- What is the demand – supply situation? Market prices for primary and secondary material are closely linked and influenced by global trends
- What are the actors along the supply chain and how to they act? For instance what incentives are given by policy makers
- What are the costs for collection and pre-treat compared to the benefits?

The role of enabling stakeholder

The role of cooperatives and middlemen is very important as they act as links between small and large stakeholders along the supply chain. Ezhea and colleagues (2013) summarises middleman and their role as primary and secondary dealers, recycling SMEs, junk shops, intermediate processors, brokers and wholesalers. They play an important role as industry demands an adequate volume of quality materials from their suppliers and will not buy materials from scavengers. In a monopolistic market (only one buyer), middlemen grossly take advantage of scavengers and paying low prices for the materials. Individual waste pickers and those who are relatively isolated on dumps are the most susceptible to exploitation as they do not have an organised supportive network.

Cooperatives are powerful means to promote grassroots developments in the informal sector. Strengthening of the organisational structure of the informal sector into formalised groups dignifies the works in the labour market and allows them to negotiate as a discrete entity. For example, they can act as a pressure group to demand regulated working hours and improved living conditions, as well as a level playing field for public health care (Ezhea et al. 2013). Moreover, having cooperatives can help facilitate access to technology and thus increase the amount and quality of the material provided to the secondary market and allow its members to react to market demand and needs more flexible. It can also lead to better prices due to pooling materials to larger volumes in a hub and thus be a more desirable partner for scrap buyers. The scale of economy factor should also not be overlooked due to different members contributing in different roles and thus can be more specialised in their roles.

Insights from the agricultural sector

While the literature on market access for the African e-waste sector is scarce, one can cross-read selected influencing factors from the food and agricultural sector where a more substantial body of literature is available, but it has to be kept in mind that there are clear difference between the e-waste and the agricultural sector, as the source of the marketable material is not linked to land but to people.
Here, relevant insights regarding remoteness are extracted from paper by Chamberlin and colleagues (2013), Fischer and colleague (2012), and Mather and colleagues (2013). The argumentation was adapted to the e-waste sector.

It is highlighted that broad brush generalisations should be avoided as market access conditions are diverse and multidimensional, although certain communalities were found in the agricultural context between remote and accessible areas. Remoteness is a limiting factor because it leads to:

Higher input and transaction costs, for instance as more transport is needed, which requires access to transportation and the use of fuel as well as more associated working hours.

Lower output prices, as there is less sales time, which might lead to selling at lower prices to avoid increasing back and forth transport cost, and fewer selling opportunities as trips to marketplace might be fewer and traders are less likely to pass by.

Limited access to markets and buyers and thus less competition between them.

Poor access to supporting services, such as credits and loans as well as information about prices, technologies and networks to understand demands better. The reduced access to technology and funding can in turn be a disincentive to adopt new technologies, which reinforced market access problems

**Additional considerations**

Particular for e-waste the informal sector is of high relevance. In some locations there can be parallel systems in place, one put in place by the local administration and one ‘informal’. Having parallel systems will increase competition and will make it market access more difficult for the formal and informal sector.

**8.1.5 Enforcement: Controlled movement for imported goods to appropriate facilities (national borders)**

As a secondary point to the access of secondary markets, is the discussion on approved transboundary movement. For some regions the import and export fees, as well as the administrative burden act as disincentives to follow legal routes to BATs for treatment and resource extraction.

A common issue that arose within the workshops was the balance between economies of scale and collection volumes against the infrastructural investments necessary to support pre-processing and remanufacturing of certain assets, components and fractions. Economically, it would not make sense to have an end processing facilities for each e-waste stream per individual country. As described in Operating Guidelines Technology, certain volumes are necessary for an installation to run at top efficiency. The ability to import and treat from neighbouring countries can be beneficial in supporting such facilities to run at optimal efficiency.

A common solution thus was to explore regional solutions, enabling trade and transport of material as renewable resources as opposed to waste. In order for this to be realized, further discussions will need to be taken with all competent authorities and stakeholders. A few first steps to enable regional solutions include:

- Capacity building of competent authorities on import and export requirements
- Digitize the Notification procedures for material
- Introduction of recognized certification and standards for approved treatment facilities in Africa

8.2 The E-waste Toolkit: The Logic Structure of Closed Loop Solutions

The most successful implementation plan of a Closing the Loop solution is to identify horizontal opportunities across all areas of an e-waste management plan, with the gradual intention to move away from a waste management and waste hierarchy philosophy to a resource management philosophy. In specific relation to EWIT, the decision trees presented for the E-waste Toolkit under the other three pillars of EWIT Operating Guidelines will include a closing the loop narrative to reinforce this thinking throughout the evaluation and implementation process. Other initiatives taken on at the municipal and national level including economic policies, environmental stewardship and job creation can also benefit from such considerations. In the final deliverable of the Toolkit, a narrative is provided (planned) to reaffirm and support the goals of a circular economy to promote resource efficiency.
Figure 6: EWIT Wizard - Collated Logic
9 Conclusions

Seeing that to truly identify closed loop solutions is a broader discussion than waste management and requires input and involvement from more stakeholders than participated in EWIT, the shared solutions varied given the diversity across geographical location, population, current and potential actors, the maturity of the existing recycling sector and the current or proposed legal frameworks.

Closing the Loop takes a systems approach to address the EHS risks and economic opportunity to increase resource conservation, reduce consumption and waste while distributing risk and value of e-waste management across the value chain. End of life management is an important aspect of circular economic thinking but is only one part of the close the loop equation. There is no one-size-fits-all model that can guarantee a sustainable closed loop thus further exploration of how to promote and incentivize such activities within the local context is encouraged.

In summary, key considerations that should be promoted and not overlooked include:

- Reuse to be promoted
- Education of the import/export authorities
- Guidelines for controlled transboundary movement of components and/or fraction
- Introduce education on e-waste in primary schools
- Consideration of safe storage and disposal of hazardous fractions
- Incentive of circular business models
- Green investment opportunities
References


EWIT work package 1: E-waste master plan for Choma, Zambia; Kisii, Kenya; Johannesburg, South Africa; Abidjan, Ivory Coast.

EWIT work package 2: Expert Modelling Workshops & Operating Guidelines – Collection, Technology, Legislation & Finance


Mather D., Boughton D., Jayne T.S. (2013) Explaining smallholder maize marketing in southern and eastern Africa: The role of market access, technology and household resource endowments. Food Policy 43, pp 248-266

