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An efficient & effective e-waste collection system for Ethiopia

Consultancy Service for UNIDO within the E-Waste Management Project in Ethiopia (EWAMP)

Freiburg & Addis Ababa, February 2015

Final Report

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List of Acronyms and Abbreviations

AU	African Union
CFL	Compact fluorescent lamp
CRT	Cathode ray tube
CRTC	Computer Refurbishing and Training Centre
DMF	Demanufacturing Facility
EEE	Electrical and electronic equipment
EEWoG	Ethiopia E-waste Management Working Group
EoL	End of Life
EPA	Environmental Protection Authority, Ethiopia
EPR	Extended Producer Responsibility
ETB	Ethiopian Birr ("Birr" – Currency of Ethiopia)
GEF	Global Environment Facility
GHS	New Ghanaian Cedi (Currency of Ghana)
ICT	Information and communication technology
KfW	German Development Bank
MCIT	Ministry of Communication and Information Technology, Ethiopia
MDSBP	Municipal Department of Sanitation, Beautification and Parks Development of Dire Dawa
MEF	Ethiopian Federal Ministry of Environment and Forest
MoFED	Ministry of Finance and Economic Development, Ethiopia
NGO	Non-Government Organisation
PAN	Pesticide Action Nexus Association
PET	Polyethylene terephthalate
PPPDS	Public Procurement and Property Disposal Service
PWB	Printed wiring board
SWCA	Solid Waste Cleaning Agency
SWRDPO	Solid Waste Recycling and Disposal Project Office
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
W1BS	Woreda 01, Bole Sub-City
WEEE	Waste electrical and electronic equipment (also known as "e-waste")

Exchange rate: 100 Ethiopian Birr (ETB) = 5.07 US Dollar (US$)[1]

[1] Exchange rate as of 9/7/2014 (Exchange Rates UK 2014)

1. Introduction

This report documents all results of the consultancy project, *Consultancy Service on an Efficient and Effective E-waste Collection System for Ethiopia* that was jointly carried out by Öko-Institut e.V. and Pesticide Action Nexus Association Ethiopia (PAN-Ethiopia) between April and December 2014. It is part of the *E-waste Management Project in Ethiopia (EWAMP Ethiopia)* supported by the GEF (GEF ID: 5040). The project is implemented by UNIDO in cooperation with the *Ethiopian Federal Ministry of Communication and Information Technology (MCIT)* and the *Ethiopian Federal Ministry of Environment and Forest (MEF)*.

The project assists the Ethiopian Government in the course of the E-waste Management Project in Ethiopia (EwaMP Ethiopia) to establish a national e-waste strategy (e-waste regulations, collection, financing, training and awareness raising), upgrade the activities of the Akaki Demanufacturing Facility (DMF), promote the cooperation with other countries in the region and link the Ethiopian e-waste treatment facilities to national, regional and international markets.

This study in particular aims at working out a proposal for an efficient and effective e-waste collection system in Ethiopia. Based on the assessment of four Ethiopian cities (Addis Ababa, Dire Dawa, Hawassa and Jigjiga, see Figure 1-1), the study shall lay the ground for a future national e-waste collection system in urban areas of the country.

More specifically, this study includes:

- an analysis of existing structures and infrastructures for collection of solid waste and e-waste in the four selected cities;
- an analysis of the functioning of the identified systems (organization, operation, financing);
- an assessment of the suitability of these structures/infrastructures for e-waste collection;
- potential roles of public and private sectors in e-waste collection;
- transportation and storage of collected e-waste;
- elaboration of incentive systems to motivate private households, businesses, government- and non-government offices to hand over e-waste to formal collection systems;
- recommendations for the installation of a pilot e-waste collection system in Addis Ababa, as well as a stepwise expansion to other Ethiopian cities/areas.

Figure 1-1: Map of Ethiopia

Source: University of Texas Libraries, Perry – Castañeda Library Map Collection.

The overall objective of the EwaMP project is to prepare the ground for an e-waste collection system all over Ethiopia. It is hence important to understand the variety of waste collection systems in place. The four cities above were selected because they are different in terms of size and population, geographical location as well as of economic power assuming that the quantities and qualities of e-waste arising as well as the structures for waste and e-waste management in place may depend on those criteria.

The scientific method of this study consists of extended literature research combined with comprehensive qualitative face to face stakeholder interviews, visual inspections and field visits between May and November 2014 in Ethiopia. Therefore, the project team carried out qualitative interviews with relevant stakeholders on solid waste management as well as the e-waste situation in the mentioned four cities in Ethiopia. The team visited public authorities, private companies, repair shops, scrap markets and dump sites (chapter 2). In parallel, existing literature on Ethiopian e-waste management and collection was evaluated as well as for Ghana and Germany comparatively (chapter 3). Based on these findings and insights, the project team derived considerations on an e-waste collection system in Ethiopia (chapter 4). A particular focus is set on the financial set-up and an incentive structure for the e-waste collection in Ethiopia (chapter 4.4). In the following, an outline for a pilot e-waste collection system in Addis Ababa including infrastructural as well as cost considerations is provided (chapter 5). Finally, the report closes with a summary and recommendations (chapter 6).

2. The solid waste management situation in four selected cities

2.1. Preliminaries: The role of informal e-waste collectors („Quorales")

As informal e-waste collectors, the so called "Quorales", play an important role in the current e-waste collection in all of the four cities covered by this study, this chapter stands at the beginning of the city specific analysis following in the next chapter.

Quorales are informal waste collectors who are acting individually. They operate in small villages, in the regions and cities, as well as in the Ethiopian capital, Addis Ababa. Their contribution in the waste management sector is, however, not well documented at a national level.

Quorales are typically young men or boys walking in residential areas with sacks on their shoulder. While walking in the residential areas, they call out loudly the word "Quorale" which is an abbreviation of "Quorkoro Yaleh" meaning "Have you got any scrap metal?" (Baudouin et al. 2010). However, the items the Quorales collect include tin cans, bottles, glass jars, perfume and nail polish containers. When households hear Quorales shouting, they – depending on the availability – offer them materials that they think the Quorales could take and negotiate the price of the items, or sometimes they just give them away for free.

According to (Maschal & Tefera 2013), the number of Quorales in Addis Ababa in the year 2013 was 4,864, all of them young men, most of them between 15-34 years old. Maschal & Tefera 2013 indicate that one Quorale in Addis Ababa on average collects commingled waste weighing 42 kg per day; of which 34% (14.3 kg) are scrap metals.

Taking the total number of 4,864 Quorales working daily in Addis Ababa, they collect 70 tons of scrap metals a day. With an average number of five working days per week, this amounts to 350 tons a week; 1,400 tons a month, and 16,800 tons of scrap metals every year only in Addis Ababa.

The Quorales bring their collected items to sell them in Merkato, the biggest open market of Ethiopia. The heart of scrap metal and other valuable waste items transaction within Merkato is a specific area called Minalesh Terra, which means “What do you have to offer centre” (Heisel and Kifle 2012).

The market of scrap metals in Minalesh Terra is highly organized with a network of middle men, shop dealers, wholesalers and recyclers. The Quorales usually sell their items to middle men and shop dealers for prices per kilogram depending on the quality of the item. The shop dealers usually provide working capital to a number of Quorales and have prior agreements to get the right to buy their collected items without competing with other dealers. The middle men and shop dealers, on the other hand, sell the items in larger quantities to wholesalers, formal recyclers (steel smelters) as well as informal recyclers.

The wholesalers collect larger amounts of scrap metals, sort out similar quality items and sell the larger chapter to formal metal recyclers and a smaller proportion to the informal recyclers.

Part of the scrap metal sheets end up in the informal recycling sector and is transformed into buckets, coffee roasting plates, kettles, sieves, scoops, charcoal stoves and similar items. Hard metals are transformed into farming and other hand tools including hoes, rakes, chisels, shovels, tongs, ploughing blades, hammers, axes, knives and similar tools. Ornamental souvenirs and religious articles from brass and aluminum are recycled by artisans. This means that artisans also play a role in the recycling chain, as they use brass and aluminum to manufacture ornamental souvenirs and religious articles (e.g. rings, necklaces, bracelets, earrings, crosses, bells).

The finished items from the informal recycling sector enter into the market chain through a network of middle men and shop dealers in Merkato to wholesalers which distribute the items in Addis Ababa and throughout Ethiopia.

Regarding the Quorales’ specific role in e-waste collection and trading within the local value chain see chapter 2.2.3.

2.2. Addis Ababa

Addis Ababa is the capital of Ethiopia and the country’s biggest city with an estimated 3 million inhabitants. It is located in the central Ethiopian highlands at 2,700 m above sea-level and both, the country’s political and economic centre. The city also hosts the African Union (AU) and several UN offices, thus signaling the city’s regional and global political importance. Furthermore, Addis Ababa is host to embassies from most foreign governments, as well as offices of many development agencies and NGOs (Manhart et al. 2013).

The city is governed by three administrative levels:

- Addis Ababa city administration (top administrative level)
- 10 Sub-cities (second administrative level)
- 116 Woredas or Districts (third administrative level)

A former fourth administrative level – the sub-districts known as *Kebele* – is not part of the official administrative structure in Addis Ababa anymore.

Information on solid waste and e-waste collection in Addis Ababa was collected during site visits and interviews carried out between the 4th and 11th of June 2014 including the following interviews and site visits:

- Public Procurement and Property Disposal Service (PPPDS)
- Federal Ministry of Environment and Forest (MEF)
- Interview with officials from Woreda 1of Bole Sub-city[2]
- Interview with two pre-collector micro-enterprises active in Bole Sub-city
- Visit to electronics repair segment of Merkato market, including interviews
- Solid Waste Recycling and Disposal Project Office
- Solid Waste Cleaning Agency
- Repi municipal landfill
- Demanufacturing Facility (DMF) in Akaki Kaliti

2.2.1. Solid waste management

Financing of the system

The framework for collecting and managing solid waste in Addis Ababa is set by the city administration. It is financed by a mandatory waste management fee raised from all registered Addis Ababa households and businesses. This fee is raised together with the monthly water-, electricity- and telephone-bill, which the *Lehulu* Government agency sends to all households. This agency acts on behalf of the *Addis Ababa Water and Sewage Authority* (water bill), the *Addis Ababa Electric Power Corporation* (electricity bill) and *Addis Ababa Telecommunication* (telephone bill). The level of the waste management fee depends on the water consumption and is therefore a progressive way of charging households for waste management[3]. Currently, the fee is set at 2% of the water bill with a minimum amount of 10 Birr (SWCA 2014). The Lehulu Government agency transfers the waste collection fees to the Woreda administration. The system so far has been working reliably.

Operation of the public system

Solid waste collection is carried out by so called *pre-collectors* that collect unsorted waste from households, businesses and public spaces (Figure 2-1). The pre-collectors are micro-enterprises (often referred to as 'associations') that have to register with the respective Woreda-administration. Typically, there are various pre-collector micro-enterprises active in one Woreda (sub-district). The collected waste is delivered to containers managed by the Woreda-administration. For each full 8 m^3 container, the municipality pays the pre-collector enterprise 400 Birr (equaling 50 Birr/m^3). The financial transaction from the municipality to the pre-collector enterprises takes place at the Woreda-administration (W1BS 2014) meaning that the municipality hands out money to the collectors.

[2] Bole Sub-city was chosen because of its diverse socio-economic structure comprising many middle and high income households. In this setting, generation of e-waste is likely to be significantly above average. As a result, it is thought that households, collectors and administration in this Sub-city have above average experiences with e-waste management challenges and potential solutions.

[3] It is assumed that households and businesses using more water also have more members and thus generate more waste.

Figure 2-1: A pre-collector of solid waste in Addis Ababa

Source: Own photography.

While there is currently no source-separation or systematic sorting of household waste, the collection micro-enterprises typically sort out valuable waste fractions at their own initiative. Interviews with pre-collector enterprises in Bole Sub-city revealed that sorting activities mostly target metals and metal containing wastes, which are sold to scrap metal buyers in Addis Ababa. Pre-collectors reported that households are also frequented by unregistered scrap collectors that specifically focus on recyclable waste, which they sell to downstream markets, mostly in Merkato market. These informal collectors are commonly referred to as “Quorales” (see chapter 2.1).

For scrap metals, the micro-enterprises reported the following characteristic price-levels (as of June 2014; an illustration of physical as well as financial flows among the actors of the scrap metal value chain is provided in chapter 2.2.3):

- Tin-cans uncompressed: 4 Birr / kg
- Ferrous metals: 8 Birr / kg
- Aluminum: 12 Birr / kg
- Copper: 50 Birr / kg
- Lead-acid batteries4: 8 Birr / kg

[4] The micro-enterprises reported that downstream markets only accept drained lead-acid batteries. Therefore, the collectors typically punch a hole into the collected batteries and drain the contained acid uncontrolled.

The pre-collector enterprises reported that e-waste is also collected from households and businesses together with mixed solid waste. The collected volumes are small as households give most used electrical and electronic equipment (EEE) to repair shops so that it does not enter the municipal waste collection system (Bole pre-collectors 2014).

Municipal waste trucks regularly transport the solid waste containers to the city's dump site in *Repi*, where the waste is disposed. The dump site itself is frequented by informal waste pickers who sort out remaining valuable parts such as unbroken glass bottles and scrap metals.

As the Repi dumpsite is a non-sanitary landfill and is running out of capacity, the city administration plans for the establishment of a new sanitary landfill in Sendafa, 36 km northeast of the city center. This landfill is planned to cover an area of 1.36 km^2 and is designed to be used for 20 years. It is also planned to develop one disposal cell for hazardous waste at this new site (SWRDPO 2014).

The municipality also plans to install three waste transfer stations in Addis Ababa (in Bole Arabmsa, Repi and Akaki Kaliti). These locations will not only act as transfer points for solid waste from pre-collectors to the municipality, but also to sort waste and to carry out recycling activities. In particular, it is planned to sort out metals and plastics and to conduct composting. Furthermore, it is envisaged to generate biogas from organic waste (SWRDPO 2014).

The three planned waste transfer stations as well as the future sanitary landfill in Sendafa form part of an integrated waste management strategy that aims to improve solid waste management, recycling and energy recovery in Addis Ababa and peripheral settlements. As part of this strategy, it is also planned to install a waste incineration plant at the Repi municipal landfill. The city administration already has an agreement with a company called *Cambridge Energy Ltd.* to install such a plant. As a preparatory step, 0.07 km^2 of the landfill are currently excavated to prepare suitable building ground. With this strategy, it is hoped that in the future, 85-90% of the municipal solid waste will be diverted from (untreated) landfilling (SWCA 2014).

Wastes from other sources than households

Large and medium sized enterprises typically organize their own waste disposal, either with own container and transport systems, or by contracting one of 17 private collection enterprises owning containers and trucks. All private companies disposing waste at the Repi dump site are charged 74 Birr/m^3 by the municipality (SWRDPO 2014).

2.2.2. E-waste collection

There is currently no formal collection of e-waste from households and businesses in Addis Ababa. As indicated in chapter 2.2.1, households mostly give obsolete electric and electronic equipment (EEE) to repair shops to restore functionality. In case the equipment proves to be beyond repair, the repair shops typically keep the devices and use them as a source of spare parts. Interviews carried out in the electronics repair shop segment of Merkato market in Addis Ababa revealed that most repair shops are frequented by scrap metal collectors ("Quorales") who buy ferrous metals, aluminum and copper (see chapter 2.1). The owner of one repair shop reported that he often strips cables with a knife in order to retrieve the copper for sale. The research team also identified various sacks filled with printed wiring boards from IT-equipment in this market segment. While no information on its use could be retrieved during the interviews, it is likely that the material is sold to scrap metal dealers[5].

[5] The type of storage (tightly packed in sacks stored in the open) speaks against reuse-purposes. In turn, the high intrinsic material value and the fact that downstream recycling markets for high grade printed wiring boards are well

Non-valuable parts (e.g. such as plastics) that are not useful for repair operations are either disposed of with the municipal solid waste collection system (see chapter 2.2.1) or stored by the repair shops. One repair shop owner reported that he had various sacks of non-functional notebook power supplies in stock, which are not needed for reuse purposes any more.

E-waste collection from federal government offices is organised by the Public Procurement and Property Disposal Service (PPPDS) under the Ministry of Finance and Economic Development (MOFED). In 2011 it issued a circular letter to all federal government offices to hand over e-waste to the Demanufacturing Facility (DMF) in Akaki Kaliti. Following this circular, various federal government offices delivered obsolete equipment to the DMF. Between October 2011 and December 2012, the DMF received 17,162 devices such as computers, uninterruptible power supplies, TVs, mobile phones, typewriters, printers and copy machines (Manhart et al. 2013). In addition, various other institutions such as the African Development Bank, The World Bank, the World Food Program as well as several NGOs located in Addis Ababa have handed over used and end-of-life EEE (Manhart et al. 2013, DMF 2014). All incoming equipment is first given to the nearby Computer Refurbishing and Training Centre (CRTC) where it undergoes functionality testing. Equipment not suitable for reuse is handed over to the DMF for dismantling. Due to the limited storage capacity of the DMF[6] the facility had to slow down collection efforts recently. However, in August 2014 first recycling outputs could be delivered to downstream markets.

Municipal government offices are not affected by this circular letter and currently have no strategy to manage e-waste from their offices. As all equipment owned by municipal government offices is registered, all disposal efforts require deregistration. To date, obsolete EEE from municipal government offices is commonly stored awaiting future management strategies (SWCA 2014).

Companies have no uniform strategy of disposing obsolete EEE. Generally, there are currently four options, namely:

- Disposal via the municipal waste collection;
- Disposal via informal collectors (Quorales);
- Disposal via repair shops;
- Storage.

2.2.3. Flows and prices of EoL devices and components along the value chain in Addis Ababa

In addition to the field research in Addis Ababa as described above, the team carried out actor specific inquiries with regard to market prices of EoL EEE and components. The purpose of this part of the field research was to gain additional insight into the price structure of EoL devices and components along the local value chain.

developed in many world regions, are an indication that the material might be sold to traders who again export the boards for recycling.

6 A new larger building for storage and dismantling operations is currently under construction and is likely to be completed in second half of 2014.

Therefore, following actors were interviewed:

- Private households
- Repair shops
- Quorales

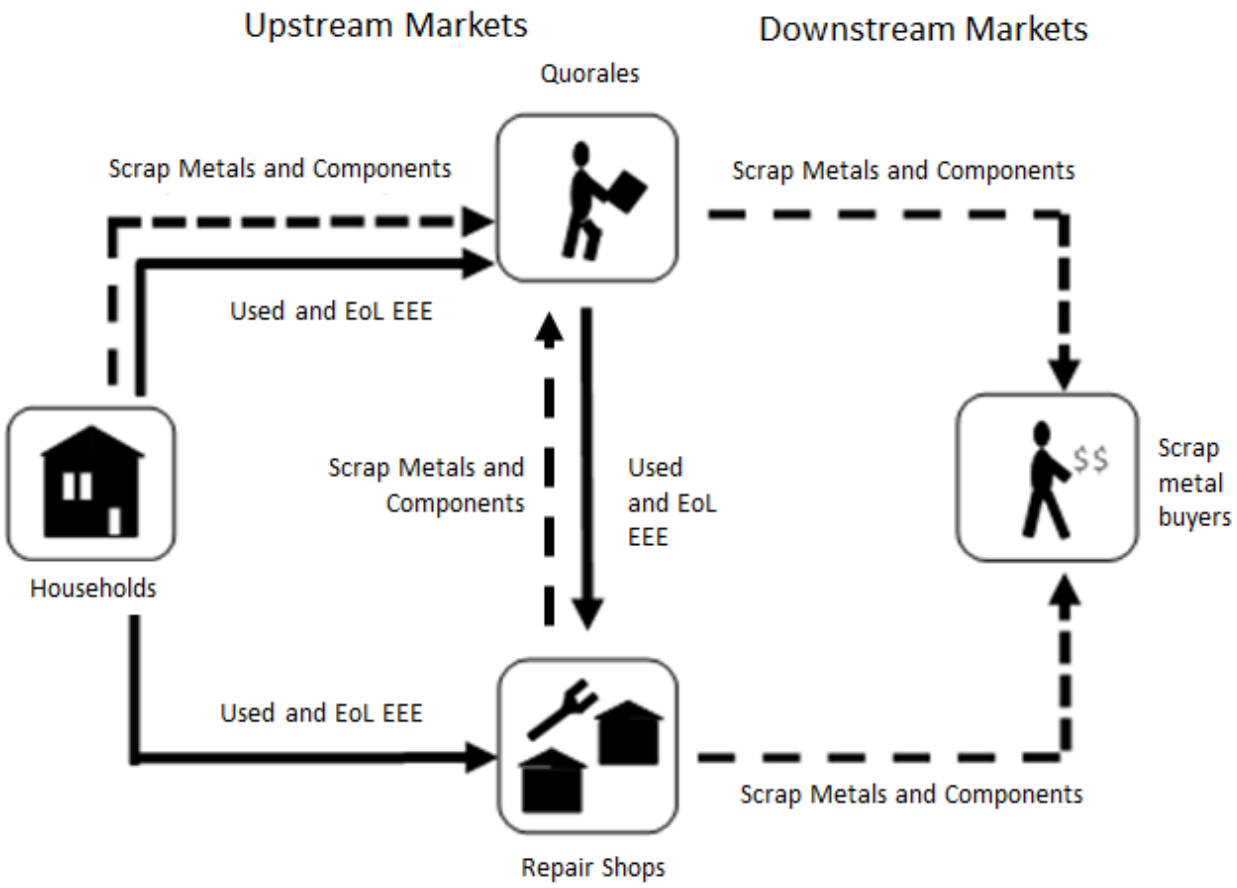
The interviews were carried out in Merkato market, Addis Ababa, between 27 October and 6 November 2014.[7] Merkato market is the central market area with regard to EoL EEE and its components. At each level of the value chain, the team consisting of 2 investigators carried out at least 10 interviews.

An overview of the flows of used and EoL EEE as well as scrap metals and components is provided in Figure 2-2. Generally, Quorales purchase both, used and EoL EEE (e.g. used and end-of-life TVs, computers, refrigerators etc.) as well as scrap metals (such as copper, steel aluminum). Repair shops typically focus on acquiring used and EoL EEE from households[8] rather than scrap metals and components. However, repair shops also purchase used and EoL EEE that were acquired by Quorales. This is motivated by the consideration, that such devices can either be repaired and sold as second-hand product, or be used as a source of spare parts for other repairs. Finally, both, Quorales and repair shops sell scrap metals and components to downstream scrap metal buyers. While this is considered to be core business of Quorales (see chapter 2.1), it is mostly regarded as a side-business of repair shops.

[7] It is important to highlight in this context that local scrap metal prices are connected to world market prices. Hence, the indicated prices in this chapter are spot market prices with regard to the period 27 October – 6 November.

[8] Most repair shops receive electrical and electronic equipment for repair. In cases a device prooves to be beyond repair, the shops usually offer a price to the owner for the broken device. In most cases, the repair shops are planning to use the device as source of spare parts for other repairs.

Figure 2-2: Flow chart of end-of-life devices and scrap metals and components in Addis Ababa



Source: Own illustration.

For the material flows and transactions illustrated in Figure 2-2, average price-levels were researched during the interview-campaign carried-out in October and November 2014.

The results of the field research with regard to EoL devices are illustrated in Table 2-1.

Table 2-1: Typical Prices for EoL EEE at different levels of the value chain

	Households sell to repair shops	Households sell to Quorales	Quorales sell to repair shops	Comments
CRT-TV (beyond repair but complete)	~ 550 Birr	~ 450 Birr	~700 Birr	The price is relatively higher when repair shops sell repaired CRT-TVs to users. Also, prices are higher when Quorales sell to repair shops compared to households selling to repair shops.
Refrigerator (beyond repair but complete)	~500 Birr	~ 600 Birr	~ 700 Birr	As source of spare parts
Desktop computer (beyond repair but complete)	~ 350 Birr	~ 450 Birr	~ 500 Birr	As source of spare parts
Computer Monitor (CRT, beyond repair but complete)	~ 150 Birr	~ 200 Birr	~ 250 Birr	As source of spare parts
Mobile phone (beyond repair but complete)	~ 50-600 Birr	~ 50-600 Birr	~ 150-700 Birr	Prices depend on quality of the mobile phones
Flat screen TV (beyond repair but complete)	-	-	-	No data. Flat screen TVs have not yet entered end-of-life stage at significant quantities in Ethiopia.
Flat screen monitor (beyond repair but complete)	-	-	-	No data. Flat screen monitors have not yet entered end-of-life stage at significant quantities in Ethiopia.

Source: Own survey.

Within the same survey, the team evaluated prices for scrap metals fully or partly retrieved from e-waste. The results are illustrated in Table 2-2.

Table 2-2: Scrap metal prices at different levels of the value chain in Addis

	Households sell to repair shops	Households sell to Quorales	Quorales sell to repair shops	Quorales and repair shops sell to metal buyers[9]	
Typical metal prices					
Steel (e.g. casing of a desktop computer) (excluding the price for cans)	-	~ 4 Birr/kg	-	~ 8 Birr/kg	Steel is sold mixed with different metals like aluminum, copper and others scraps.
Aluminum (e.g. Hard disk drive, without high grade PCB)	-	~ 6 Birr/kg	-	~ 12 Birr/kg	
Copper (e.g. electron gun from CRT TVs)	-	~ 20-30 Birr/kg	-	~ 40-50 Birr/kg	
Cables (short cables of different strengths)	-	~ 3 Birr/kg	-	~ 4 Birr/kg	Usually households do not sell cables. They throw the cables of any type together with the household solid wastes.
High Grade Printed wiring boards (PWBs) (green boards)	-	-	-	~ 4.50 Birr/kg	Households do not sell PWB as they usually sell intact EEE materials.
Mid or low grade Printed wiring boards (PWBs). Red, yellow or brown colours.	-	-	-	~ 2 Birr/kg	Same as above

Source: Own survey.

[9] In this context metal buyers are the scrap metal traders (“middle men”) rather than the smelters.

The data illustrated in Table 2-2 is used for deriving a dynamic incentive structure to be used in a pilot e-waste collection system in Addis Ababa (see chapter 5).

2.3. Dire Dawa

Dire Dawa City is located 505 km to the east of Addis Ababa, and is the nearest urban center to the border between Ethiopia and Djibouti. It is one of the metropolitan city administrations in Ethiopia (PAN 2012).[10] According to Manhart et al. (2013) the city has a population of 262,884 persons. Dire Dawa City has two administrative levels: City Administration (Municipality) at the top, and nine urban Kebeles and 31 rural Kebeles as subdivisions. Kebeles have administrative functions within their boundaries in accordance with the principle of decentralization and in cooperation with the main City Administration (PAN 2012).

The project team conducted field research with a focus on the collection and management of solid waste in Dire Dawa City from 5th– 7th of June 2014. The following institutions were interviewed and site visits have been carried out:

- Dire Dawa City Administration Environmental Protection Authority (DDCA-EPA),
- Municipal Department of Sanitation, Beautification and Parks Development of Dire Dawa (MDSBP),
- Visit of the Sanctuary Solid Waste Landfill Site of Dire Dawa.

2.3.1. Solid waste management

Solid waste collection in Dire Dawa is organized on the level of the Kebeles. After conducting a study on the needs of solid waste collection, the Dire Dawa City Administration Environmental Protection Authority started a pilot project on solid waste collection in Kebele 09 in 2010.The main reasons for this were poor collection rates and a comparatively high solid waste pollution in Kebele 09 that consists of around 500 households.

In Kebele 09, two associations collect waste from house-to-house:

- Tamesalet solid waste pre-collectors and reuse Association,
- Maradadat solid waste pre-collectors and reuse Association.

In 2010, altogether 8 solid waste collection associations were registered in Dire Dawa. Currently, only the indicated two companies are still active. According to DDCA-EPA (2014), both associations altogether employ 55 pre-collectors (“waste pickers”) that have to be registered within one of the two associations. They are typically recruited from a socially ostracized segment of the city’s society.

[10] This means that the city administration of Dire Dawa is not influenced by any other regional government.

2.3.1.1. Financing of the system

For the price of 10 Birr (~0.5 USD) per month and household, the waste collectors visit the households two to three times per week. This price is the common market price for the collection service in Dire Dawa. The collectors take the solid waste to the local solid waste containers (Figure 2-11). The households directly pay the waste pickers during their visits (in cash) financing the associations. Generally, solid waste is not sorted.[11]

2.3.1.2. Operation of the system

Each Kebele[12] of Dire Dawa is equipped with at least one solid waste container. Altogether the Municipal Department of Sanitation, Beautification and Parks Development of Dire Dawa runs around 100 containers (MDoSBPD 2014). In the Kebeles others than Kebele 09, the collection of solid waste is organized by the communities themselves without an association. Typically, household members take solid waste to the containers directly.

Apart from the registered waste associations, informal waste collectors are active in Dire Dawa (DDCA-EPA 2014), who also collects e-waste. These “Quorales” are not registered in one of the waste collection associations but operate individually (see also chapter 2.1). They are engaged in buying (collecting) valuable items from households including EoL EEE and its components. According to representatives of the Municipal Department of Sanitation, Beautification and Parks Development, e-waste and its components (cables or whole devices such as TVs) typically do not arrive at the city’s landfill. The Quorales sell them to repair shops that use the devices and components as spare parts.

[11] However, within a pilot project the pre-collectors sort biodegradable waste from non-degradable and try to use the degradable waste for composting.

[12] Typically, one Kebele consists of several thousand people.

Figure 2-3: Solid waste transfer station in Kebele 09 in Dire Dawa

Source: Own photography.

Municipal trucks transport full containers to the local sanitary solid waste landfill (Figure 2-4). There, the solid waste is not weighed but just disposed of. The local sanitary landfill site was built in 2002 with funding of the German Development Bank (KfW). It is a state of the art sanitary landfill site with one big cell for household waste and two basins(one anaerobic and one aerobic) for a basic treatment of leachates collected from the solid waste cell (MDoSBPD 2014).

Figure 2-4: Sanitary landfill site in Dire Dawa

Source: Own photography.

During a visit of the waste disposal site, no obvious e-waste or components and fractions thereof could be spotted, which supports the earlier information that these items are rather accumulating in repair shops.

2.3.2. E-waste management

As no significant quantities of e-waste enter the solid waste stream in Dire Dawa, repair and maintenance shops, individual repairers of EEE as well as scrap collectors were visited and interviewed in the following districts and markets:

- Kafira Market area,
- Repair Shops in Sabian,
- Conel Market area,
- RuzeTera (“Rice Market”) area.

Generally, all interviewed repair shop owners and employees said that they are not aware of the environmental and health implications of unsound e-waste management. They usually buy used and obsolete EEE from Quorales to use them as source of spare parts. Parts and devices that are not useful for repairs anymore will enter the solid waste stream.

In Kafira Scrap Market some (informal) collectors are specialized on the repair of electrical and electronic devices (Figure 2-5). Therefore, they purchase EoL EEE as well as components from customers and informal e-waste collectors (“Quorales”). The devices and components are stored in locked backyard garages as source of spare parts. The repairers assured that they would hardly dispose or give away e-waste components as most components could be used for repair. In case components would be beyond use for repair they would give it to Quorales (see chapter 2.1 and 2.2.3).

Figure 2-5: Repair of a ventilator in Kafira Market

Source: Own photography.

The different repair shops in the town of Dire Dawa are specialized on electrical and electronic devices such as desktop computers, CRT-TVs, mobile phones or appliances such as ventilators. Accordingly, EoL components that are of no further use are stored in small sacks and sold to Quorales. Steel and aluminum not required for repairs are sold to Kafira Market (see above).

Figure 2-6: Workplace of a mobile phone repair shop in Dire Dawa (left) and a repairer of electronic equipment at Rice Market in Dire Dawa (right)

Source: Own photography.

In addition to repair shops, independent repairers (without a shop) in the Conel and Rice Market are repairing electronic equipment such as DVD players, CRT-TVs etc. In case the equipment cannot be repaired, they still purchase such EoL EEE from their customers as a source of spare parts. If components are not suitable for re-use, valuable fractions are sold to informal collectors. Residual, non-valuable fractions (e.g. plastics of cassettes) go into the solid waste stream (see chapter 2.3.1).

2.4. Hawassa

Hawassa is the capital of the Southern Nations Nationalities and Peoples Region (SNNPR) and is situated 270 km south of Addis Ababa on the shores of Lake Hawassa on the major road connecting central Ethiopia with Kenya to the south. The city has an estimated population of 212,665 people and ranks 6 amongst Ethiopia's biggest cities (Manhart et al. 2013). Information on solid waste and e-waste collection in Hawassa was collected during site visits and interviews carried out between the 5th and 7th of June 2014. The following interviews and site visits were carried out:

- Municipality of Hawassa
- Natural Resource and Environmental Protection Office (Hawassa)
- Visit to the municipal dump site
- Interview and two site visits to Wub Hibir Solid Waste Cleaning and City Beautification Services Enterprise
- Site visit to Yichalal Association, that is active in waste collection
- Site visit to various repair shops for mobile phones and other electrical and electronic equipment

2.4.1. Solid waste management

The framework for collecting and managing solid waste in Hawassa is set by the municipality. Solid waste collection from private households is carried out by individuals and 9 associations, which are registered at the municipality.

The associations employ pre-collectors that collect unsorted solid waste. Nevertheless, waste pickers typically sort-out valuable waste such as metal parts and (unbroken) glass bottles on their own initiative.[13] The non-valuable waste is brought to transfer stations and waste containers evenly distributed across the city. Currently, 42 containers of 1 m^3 and 25 containers of 8 m^3 are in use in Hawassa. Municipal waste trucks transport the solid waste containers to the city's landfill site (Municipality of Hawassa 2014).

2.4.1.1. Financing of the system

Pre-collectors make arrangements with households to pick-up their waste for a monthly fee. This fee is directly paid by households to the pre-collectors. The municipality regulates the amount of the fee, which is currently 10 Birr per month for a household with five persons.[14]

2.4.1.2. Operation of the system

For the household collection itself, pre-collectors commonly use donkey-carts and in some cases own push-containers and/or pickup-cars (see Figure 2-1).

It is noteworthy that households are not obliged to enter arrangements with pre-collectors. Alternatively, they can also save the collection fee and apply own management practices (e.g. transport to nearest municipal waste container). Although there is no systematic monitoring of irregular dumping of households, Hawassa is known to be one of the cleanest cities in Ethiopia, which is an indication that irregular disposal is not systematically practiced.

About one year ago, the German *Gesellschaft für Internationale Zusammenarbeit (GIZ)* initiated a pilot project in source separation. In this pilot, 10,000 Hawassa households were equipped with different types of bags to separate the following waste types:

- Organic waste
- Plastic waste
- Metal-containing waste and glass
- Other types of waste (residues)

Although the pilot project proved that many households can be convinced to conduct source separation, a lack of downstream solutions for organic waste and plastic waste resulted in the disposal of three of the four fractions on the city's landfill site. For this reason, the source separation will not be continued (Municipality of Hawassa 2014).

Representatives from the municipality reported that pre-collectors repeatedly complain about households not willing to pay their monthly fees – despite prior bilateral arrangements. For this reason, the municipality considers to change the system to a general waste management fee that

[13] Pre-collectors are formally employed at the waste collection associations. Waste pickers, however, are independent persons that sort out valuable fractions at disposal sites ("informal sector").

[14] Regarding the determination of the waste collection price, there is no such thing as a system or a calculation. Moreover, it as ben set politically.

is raised together with the water-bill (see chapter 2.2.1 on Addis Ababa). No final decision has been made yet on a system reform (Municipality of Hawassa 2014).

Two of the 9 registered pre-collector associations for household waste are conducting systematic waste sorting activities. For these activities, they were given municipal land in the outskirts of the city to use free of charge. The *Yichalal Association* focuses on composting of animal manure, which is sold to a nearby tree nursery owned by the city's *Natural Resource and Environmental Protection Office*. The *Wub Hibir Solid Waste Cleaning and City Beautification Services Enterprise* sorts out various types of wastes[15], including:

- Metals
- Textiles/rags
- Shoes
- PET-bottles
- Mixed plastic foils
- Glass bottles (unbroken)
- Glass (broken)
- Cardboard
- E-waste

In addition, the enterprise is planning to produce compost from sorted municipal waste. While metals (mix of ferrous metals and aluminum) are currently sold at 5 Birr / kg to scrap metal buyers, also PET-bottles find a downstream recycling market. Intact glass bottles and shoes are sold for reuse purposes. The other fractions are currently stored hoping for future downstream markets (Wub Hibir 2014).

In addition to the household collection, the municipality directly engages 28 associations with a total of 911 individuals to pick waste from streets and public property (Municipality of Hawassa 2014).

2.4.1.3. Wastes from other sources than households

Companies have various ways to deal with their waste: While large companies typically have own waste containers, which are regularly picked up and emptied by municipal waste trucks. Mid-sized businesses like hotels and larger businesses often organize their own waste transport to the landfill. Small businesses mostly make arrangements with pre-collectors and pay monthly fees ranging from 25 Birr to 150 Birr for the pick-up service.

2.4.2. E-waste collection

The only e-waste related collection activity in Hawassa is the sorting initiative of *WubHibir Solid Waste Cleaning and City Beautification Services Enterprise* (see chapter 2.4.1). E-waste sorting was started just one month prior to the interview. The e-waste picked from the collected household waste mostly consists of mobile phone chargers, cassettes, power sockets and some cables. In terms of volumes, collection and sorting activities of two weeks yielded various kilograms of e-waste (see Figure 2-7).

[15] As the two associations address quite different type of waste streams and qualities, there are to date no obvious synergies between the two initiatives.

Figure 2-7: E-waste sorted out from the solid waste collection in Hawassa by Wub Hibir Solid Waste Cleaning and City Beautification Services Enterprise.

Source: Own photography.

The company's manager reported that other types of e-waste (e.g. TVs, computers) are typically not entering the municipal waste stream but – once obsolete – are handed over to repair shops, which use non-repairable devices as a source of spare parts (Wub Hibir 2014). This information was confirmed by visits to various repair shops for mobile phones and other devices in Hawassa. These entities are typically given non-functional equipment for repair. In case the devices prove unrepairable, they are taken over by the repair shops and used as source of spare parts. In one case, the research team was shown significant stocks of printed wiring boards from TVs as well as other parts from fridges, printers and computers (see Figure 2-8).

Figure 2-8: Spare parts stored in one repair enterprise for electric and electronic equipment in Hawassa

Source: Own photography.

Metals not useful for repair are sold to informal collectors (Quorales). Non-valuable parts that are unsuitable for repair operations are either stored or given to pre-collectors for disposal. One pre-collector association reported that they are given one sack of worthless waste (plastics etc.) from mobile phone repair shops per week, which they are told to dispose of at the municipal dump site.

Regarding e-waste from municipal offices, no strategy has been defined yet. In the past, it was tried to tender non-functional and de-registered computers to bidders. Nevertheless, this strategy did not yet lead to any transaction as bidders have not been satisfied with the quality of the devices.

2.5. Jigjiga

Jigjiga is the capital city of Ethiopian Somali regional state which is located 625 km to the east of Addis Ababa. The city, which is situated 60 km from the border of Somaliland[16], has 147,482 dwellers (see Table 4-1). The city has two layers of administration: the Jigjiga City Administration and 11 Kebeles of the city. The city has the same administrative structures like the other surveyed cities and splits into 11 Kebeles. Jigjiga is also known as the main destination for smuggled electrical and electronic equipment (EEE) from Somaliland and Djibouti.

[16] Somali Land used to be part of Somalia but now declared as an independent country by itself.

Information on solid waste management and e-waste collection and EEE trade in Jigjiga was collected from the 14th - 16th of July and 3rd – 7th November 2014. The following interviews and site visits were carried out:

- Somali Region Environmental Protection, Energy and Mineral Development Agency
- Jigjiga Town Sanitation and Beautification Agency
- Visit to EEE repair shops at Kebele 02 market
- Interview with EEE selling shops at the old and new Taiwan markets

2.5.1. Solid waste management

Solid waste collection in Jigjiga is organized by the City Sanitation and Beautification Agency and its subsidiaries in the 11 Kebeles. In addition to the agency, there were five solid waste management enterprises that are no longer active today. These five enterprises were organized in 2012/13 to collect household waste in partnership with the city administration. The reason why they stopped operation could not be identified. Taking the importance of solid waste collection enterprises into consideration, the agency is now organizing three new enterprises within the City Youth Association to engage in solid waste collection. These three enterprises are now at the trial stage. They are accountable to the Agency and the City Youth Association. The number of their members and the area to be covered by each of the enterprises is not specified yet.

As per the information from the Agency, if these three enterprises become fully functional, the solid waste collection in the city will have two levels:

1) the enterprises collecting solid waste from house to house based on mutual agreement with households on how much the solid waste collection fee could be and

2) the agency collecting waste with trucks from households of the 11 Kebeles in 2-3 days per week (Figure 2-9).

Within the two levels of waste collection, the system of payment for the service is not yet established.

Figure 2-9: Solid waste collection from house to house by municipal trucks in Jigjiga

Source: Own photography.

The city has 53 solid waste handover points where the solid waste collection enterprises as well as households and businesses not using the services of waste collection enterprises can dispose their unsorted waste. The waste from the 53 transfer stations is carried by municipal trucks to the open dump site, which is located 7 km outside the city center.

2.5.2. E-waste management

With regards to e-waste management, the City Sanitation and Beautification Agency and the Somali Region Environmental Protection, Energy and Mineral Development Agency indicated that they do not have any strategy in place. The respective interview partners indicated that they just heard about the environmental and human health impacts of unsound e-waste management from the study team. They, however, confirmed that non-reusable components of electrical and electronic equipment (EEE) end up with municipal solid waste for final disposal at the dump site.

Apart from this stream, repair shops play a crucial role in the management of used and end-of-life EEE. According to the information obtained from repairers of Kebele 02, they receive repairable EEE from households and institutions. If the equipment can be repaired, the owner pays a service fee and takes away the device for prolonged use. If the equipment cannot be repaired, the repair shops typically negotiate and buy the non-functional equipment for future use as source of spare parts. The types of items they receive for repair range from mobile phones, DVD players, computers and TV sets to refrigerators.

Figure 2-10: Electronic repairer opening CRT TV to repair (left) and refrigerators collected for repair (right) in Kebele02 market, Jigjiga

Source: Own photography.

As in other cities, informal collectors of valuable waste fractions (“Quorales”) are also active in e-waste collection. Typically, these collectors sell used and end-of-life EEE collected from households and businesses to repair shops. Therefore, the repair shops also receive some repairable EEE and components that can be used for future repairs from the Quorales.

In turn, repair shops sell ferrous metals, aluminum and copper retrieved from obsolete EEE back to the Quorales. In contrast to the situation in other cities, these metals are not traded individually, but as mixed metals. In July 2014, the price for mixed metals from e-waste was 7 Birr per kg. Plastics, end of life CRT tubes and other non-reusable components of EEE are being disposed at the dump site.

The interviews and visits carried out at the market of Kebele 02 indicated that repair shops are not aware of the potential environmental and human health impact of unsound e-waste management.

As Jigjiga is an entry point for different types of smuggled electrical and electronic equipment, it might experience an above average accumulation of e-waste in the future.

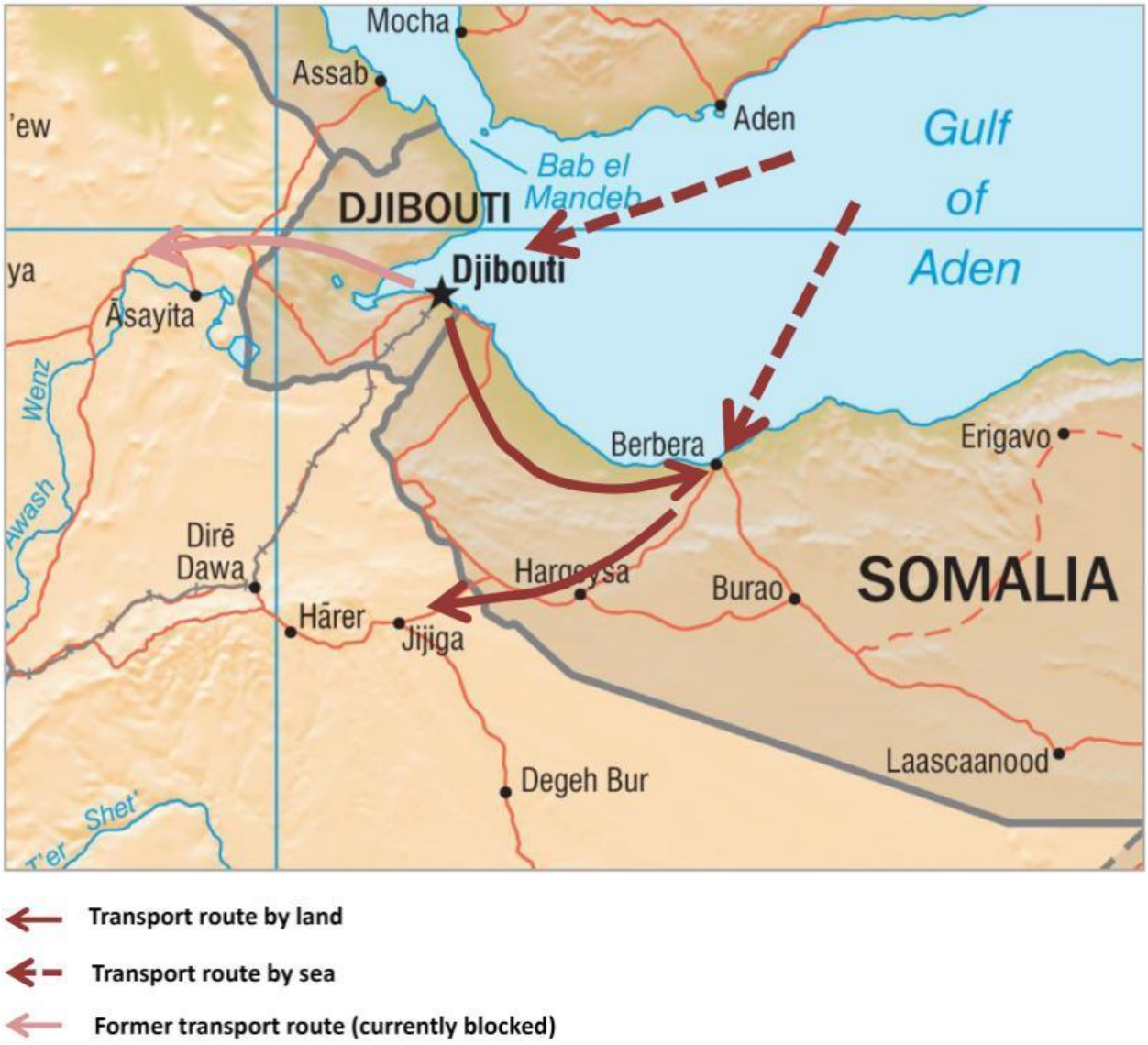
2.5.3. Smuggling of electrical and electronic equipment

Jigjiga is widely known for being a hub for illegal imports of EEE, which is mostly brought into the country via the close border to Somaliland. Field research carried-out in July and November 2014 revealed the following information on this trade.

According to the information from the shop owners, the ports of Somaliland and Djibouti are the main sources of EEE smuggled to Jigjiga. The first and most frequented route starts from Djibouti and leads via Berbera (Somaliland) to Togochale[17] and finally to Jigjiga (see Figure 2-11). While on the first part of this route from Djibouti to Berbera, transport is usually conducted by big trucks, the way from Berbera to Jigjiga is mostly managed by smaller vehicles.

[17] Togochale is a small Ethiopian town at the boarder of Somali Land, 45 km from Jigjiga.

Figure 2-11: Transport routes for EEE illegally imported into Ethiopia



Source: Own assessment. Map: University of Texas Libraries, Perry-Castañeda Library Map Collection

The second, shorter route is the one which receives EEE from the port of Berbera, this EEE does not come from Djibouti but from other sources via ship. This EEE is passed on to Togochale and then ends up in Jigjiga. The amount of equipment that reaches Jigjiga from this route is smaller than that being imported via Djibouti.

Previously, there was another smuggling route from Djibouti into Ethiopia via the Afar region that avoided Jigjiga completely. This more direct route avoided the detour via Somaliland but is now thoroughly controlled by the Ethiopian Government (see light red arrow Figure 2-11). According to anecdotal information, the prices for EEE in the Afar region are today less favorable than some years ago and are sometimes even above price levels in Addis Ababa.

In order to combat illegal EEE imports, the government set-up a control system based on checkpoints on the main road connecting Jigjiga with Somaliland. Nevertheless, the border between Somaliland and Ethiopia is porous and smugglers can use various alternative routes. In

addition, smugglers maintain communication networks with people who can scout and tell them the times when the road is uncontrolled.

In Jigjiga, the smuggled EEE is sold on the Old and New Taiwan Markets to customers mostly coming from other parts of Ethiopia. A more detailed description of the two markets is given in chapter 2.5.4.

Apart from Jigjiga, also Harrar and Dire Dawa are known to host markets with smuggled EEE. These markets are mainly supplied via Jigjiga.

Until recently, smuggled EEE used to be traded on to Harrar, Dire Dawa and even Addis Ababa on a large scale. However, in the last years, the government regularly sets-up control check points on the roads connecting Jigjiga with other Ethiopian cities. Therefore, the trade between Jigjiga and other Ethiopian cities is currently mostly organized in small transports. In addition, organized networks continuously try to find ways to avoid checkpoints – either by using alternative routes, or by collecting information on time and location of government checkpoints.

Smuggling focuses predominantly on new equipment. Although second-hand devices might – on a case-to-case basis – also be smuggled, the market share of used equipment is well below 5%. Notebooks and Desktop PCs were observed to be the product group where used equipment is most common.

There is no explicit focus on certain product groups. As indicated in Table 2-3, all types of EEE are smuggled via the described routes. Here, it has to be stressed that also other goods such as clothes and shoes are smuggled together with EEE.

Smuggling is mostly motivated by the opportunity to save import taxes that range from 20 % to 50 % depending on the type of EEE. Thus, the smuggled EEE in Jigjiga can be sold at significantly lower prices than comparable devices in Addis Ababa or other Ethiopian cities.

It was calculated that in Jigjiga devices are sold on average at prices of around 1/3 of those in Addis Ababa[18]. While this price-level can partly be explained by tax evasion, other factors encompass lower rents for shops and storage space in Jigjiga compared to Addis Ababa, as well as the fact that the demand for EEE is much lower in Jigjiga[19] while at the same time the offer is high.

[18] As an example, a new Samsung galaxy smartphone that is worth 4,500 Birr in Addis Ababa can be bought for 1,500 Birr in Jigjiga. A 42-inch LED 3D-TV by LG can be purchased for 10,000 Birr in Jigjiga and would cost 35,000 Birr in Addis Ababa.

[19] After all, customers buying EEE in Jigjiga still have to care for the transport of EEE to its final destination. As the road distance between Jigjiga and Addis Ababa is 625 km, also the uncertainties from checkpoints and controls play a role and are reflected in the comparatively low EEE-prices in Jigjiga.

Table 2-3: List of smuggled electrical and electronic equipment observed in shops in Jigjiga

Television & accessories	Computer & accessories	Mobile devices & accessories	Other electronic items
• Television • DVD player • Decoder • Satellite dish • Receiver cables	• Laptops • Desktop computers • CD-R, CD-RW & DVD • computer speakers • Hard drives • USB sticks • CDMA sticks • Printers • Notebooks • Computer, keyboards & mouse	• Mobile phones • Mobile chargers (separate) • Mobile phone batteries • Head sets	• Radios • Tape recorders • Stoves • Ironing machine • Power adaptor • Power dividers • Rechargeable batteries • Men and women beauty equipment • Power cables • Different types of lamps • Refrigerators • Air conditioner • Dry cell batteries • Washing machines • Coffee grinder • Juice maker • Kettles • Vacuum cleaners • Photo and video cameras • Megaphones and • Meat grinder

Source: Own survey.

However, it was not possible to quantify the amount of EEE smuggled into Ethiopia. The observation of regular roadside controls between eastern Ethiopian cities (such as Jigjiga, Dire Dawa) and other cities (such as Addis Ababa) by government authorities aiming at uncovering smuggling activities is a strong indication that smuggling of EEE is still a considerable problem.

2.5.4. EEE markets in Jigjiga

Electrical and electronic equipment is mainly sold in the so called Old and New Taiwan Markets. The names of these markets are references to the country of Taiwan, where a large portion of the world's electrical and electronic equipment is designed. As the markets are major hubs for illegally imported EEE, field research could only refer to transect walks and sporadic interviews. For security reasons, no pictures could be taken.

The Old Taiwan Market is located around the center of the town and covers an area of 0.24 km^2. The New Taiwan Market is located about two kilometers away from the center and occupies 0.3 km^2. Currently, the shops of the Old Taiwan Market are being relocated to the New Taiwan Market with a view to completely close down the Old Taiwan Market in the near future. Some shop-buildings of the Old Taiwan Market have already been demolished by the authorities. At the time of visit (November 2014), the Old Taiwan Market still comprised 75 shops, whereof the larger shops

have a floor-space of 30-50 m^2 and around 4 to 6 employees.[20] The recently established New Taiwan Market already housed 174 shops in November 2014 with 12 shops of larger size (floor-space > $30m^2$).[21] In both markets, most shops deal with a broad variety of EEE. In most cases, shops even sell non-EEE items such as cloths, food and household materials.

In addition to the shops in the Taiwan Markets, there are 53 shops distributed over town that also sell electrical and electronic equipment. These shops are comparable to those of the Taiwan Markets in terms of size and product portfolio.

The Old and New Taiwan Markets are usually open from 08:00 am to 07:00 pm. The shops in town usually open between 08:00 am and 09:00 pm. While many shops are open seven days a week, some shops may be closed during religious holidays depending on the religion of the shop owners. Shops owned by Muslims usually do not open on Fridays.

All shops hand out most – if not all – products without receipt, which indicates that devices were smuggled into Ethiopia (see chapter 2.5.3).

During the time of visits, most EEE shops were very busy with at least one customer in the shop at a time. During peak periods (morning and late afternoon when the heat is less intense), it is also common that customers need to wait up to 5 minutes or more to be served. The markets are most frequented on weekends (Saturday and Sunday) as many customers from other cities usually use weekends for shopping in Jigjiga.

Compared to other Ethiopian cities of comparable size, the markets for EEE in Jigjiga are clearly above average in terms of size and number of persons working there. At the time of visit, the markets were very lively with many people buying EEE and non-EEE items like clothes. In addition to the organized trade described in chapter 2.5.3, individuals who visit Jigjiga for business or personal reasons usually buy some electrical and electronic devices to take them to the central part of Ethiopia mostly without being charged by the check points at road sides. There are, however, cases of individuals claiming that even single EEE was confiscated by the customs offices. If someone carries a significant amount of EEE exceeding the amount for personal use, the customs office on the check points confiscates the whole lot and in many cases the individuals caught with these items are sued for smuggling goods.

Considerations and implications of smuggling of EEE into Ethiopia for an EPR-System are provided in chapter 4.4.

3. E-Waste collection systems in other world regions

In the following chapters the e-waste collection systems of Germany and Ghana are described and compared. Based on this, considerations for an e-waste collection system in Ethiopia are derived in chapter 4.

3.1. E-waste collection in Germany

The legal basis for e-waste collection in Germany is the European Directive 2002/96/EC of the European Parliament and the Council on Waste Electrical and Electronic Equipment (so called WEEE-Directive) that came into force in 2003. Consequently, the WEEE-Directive had been

[20] The shops are usually housed in small concrete buildings without basement or first floor. Only two buildings had a first floor.

[21] It is organized in straight rows with small concrete shop-buildings lining-up at both sides.

implemented into German Law within the ElektroG (Act governing the Sale, Return and Environmentally Sound Disposal of Electrical and Electronic Equipment) in 2005. In 2012 the European WEEE-Directive had been revised resulting in the new WEEE Directive 2012/19/EU (so called recast WEEE Directive) which entered into force in February 2014. Accordingly, the German ElekroG is currently under revision (WEEE 2012; ElektroG 2005).

A basic principle of both, the WEEE Directive and the ElektroG, is the approach of Extended Producer Responsibility (EPR). The basic idea of an EPR approach is to incentivize producers to minimize end-of-life (EoL) costs of their products by adopting product design to the needs of recycling. For this, the responsibility of financing the organisation, pickup and transport to treatment as well as treatment of e-waste is transferred to them. Within this, the European WEEE Directive sets mandatory responsibilities on Producers and Distributors within all member states of the European Union. Particularly, the Directive rules that (1) producers have to *set up systems for the treatment of e-waste* using best available treatment techniques, (2) producers must at least *finance the collection, treatment and environmentally sound disposal* of e-waste from private households delivered to collection depots and (3) each producer must *finance the treatment of the waste from its own products*. These obligations can be met individually or by joining a collective scheme (Deubzer 2011).

Additional to the above stated obligations, producers have to (1) provide a guarantee that collection, treatment and disposal of a device put on the market is financed, (2) mark the product with a symbol (label) and (3) achieve certain minimum targets for recovery and recycling. Within the recast WEEE Directive 2012 from 2016 on, the minimum collection rate of the total weight of WEEE collected shall be 45% expressed as a percentage of the average weight of EEE placed on the market of the three precedent years of the respective Member State. This rate shall increase gradually up to 65 % in 2019 (alternatively 85% of WEEE generated on the territory of the member state).

Within certain degrees of freedom, Germany has implemented the previous WEEE Directive in the ElektroG, while the recast WEEE Directive is not yet transmitted into German national legislation[22]. In Germany, key players are public waste management authorities, private producers of electrical and electronic equipment and the clearing house (EAR: “Elektro-Altgeräte Register”) which is private with governmental authorization (UBA 2014).

Generally, the public waste management authorities are responsible for the collection of e-waste. They set up collection points where end users and distributors can deliver e-waste from private households *free of charge*. For this reason, the system is often called a “bring back system”. Commercial collection, however, is not possible via this channel but has to be tendered to third parties, possibly private companies (UBA 2014).

Whereas the WEEE-Directive categorises ten e-waste categories (see Annex I), at the collection points in Germany e-waste is only separated into five categories: (1) Large Household Appliances, Automatic Dispersers, (2) Large Household Appliances, (3) Information and Telecommunication Equipment (ICT) and Consumer Electronics, (4) Lighting Equipment and (5) Small Household Appliances as residual WEEE-classes. This compromise allows for sufficient separation with regard to efficient treatment as well as a practical collection. Accordingly, the public waste management authorities forward the e-waste in these five fractions free of charge.

At this point, producers take over the e-waste from municipal collection points or directly from distributors. As public waste management authorities and producers share the responsibility the

[22] Status: January 2015.

overall principle of the ElektroG is also called “Shared Product Responsibility”. According to the ElektroG producers can choose whether they set up

- an individual brand-selective take-back scheme (ITBS),
- an individual non-selective take-back scheme (INTS) or
- join a collective take-back scheme (CTS).

In any case, producers do not operate EoL equipment themselves but contract so called end-of-life service providers (ESPs) that execute logistics, treatment and disposal (Deubzer 2011).

A special case is the individual brand-selective scheme, as producers only take back devices of their own brand. Public waste management authorities have to collect and store the respective brands separately or the producers establish an own collection point. Here, the amount of e-waste that has to be collected depends on the market share of the EEE of the brand put on the market. The respective market share is calculated by the clearing house (EAR 2014). In the case of an individual non-selective take-back scheme (INTS) producers do not only take back their own brand products but the amount of e-waste (independent of the brand of the EoL devices) according to its market share. The majority of the producers marketing EEE in Germany, however, join a collective take-back scheme. Hence, several producers organize and finance EoL of their products together. The collective system has to take back the amount of e-waste according to the market share of the devices put on the market by the member companies together (UBA 2014).

Within the EPR system implemented in Germany (ElektroG), distributors (e.g. retailers) take back e-waste voluntarily. In contrast to some other EU member states and to Switzerland, distributor take back is not mandatory in Germany. However, typically retailors trade in EoL EEE from end-users in case of purchase of a new device. Consumers are obliged by the ElektroG to deliver e-waste separately from other unsorted domestic waste. This obligation holds equally for distributors, even if they do not have to hand over e-waste to public authorities (recycling depots) or to producer take-back system. They can deal the e-waste independently such as cooperate consumers.

A special role within Germany’s implementation of the WEEE-Directive plays the clearing house, called “Elektro-Altgeräte Register” (EAR). Principally, it is responsible to coordinate the activities of the different actors such as the public waste management authorities and the producers as well as to monitor individual take back schemes (EAR 2014). The EAR is organised as a foundation. The central task of the clearing house (EAR) is to register producers, to calculate the producer’s market share for the purpose of the above described producer’s responsibilities and to report on this. The clearing house (EPR) is authorized by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety to execute Federal Law such as the mandatory producer registration and charges the producers accordingly. For a detailed elaboration of the role of the clearing house (EAR) see Deubzer 2011.

3.2. E-waste collection in Ghana

Ghana has been in the center of the debate around unsound management of e-waste in the African context. While the international attention focuses on the imports of used and end-of-life EEE from other world regions, domestically generated e-waste also plays quite a significant role and contributed 179,000 tons to the total e-waste generated in Ghana in 2011 (Schluep et al. 2012). The UNEP E-waste Africa Project showed that this e-waste generation together with a well-developed informal scrap metal market stimulated quite intensive collection efforts carried out by informal collectors commonly referred to as 'scavengers'. These informal collectors typically use push-carts to move around urban areas and to ask at private households and businesses for all types of metal containing wastes. In particular in large cities such as Accra and Tema, e-waste makes up an important share of their total collection volume. It is estimated that these collectors manage to collect 95 % of all domestically generated e-waste (Schluep et al. 2012), which represents an outstandingly high figure. Generally, this high collection-rate is achieved because informal collectors offer cash-money to households and businesses for e-waste. While there is no uniform price-structure, market prices for devices such as end-of-life TVs and end-of-life refrigerators are widely known in major urban areas (Prakash & Manhart 2010).

Nevertheless, the collected e-waste is exclusively steered into the informal recycling systems, which are associated with severe impacts on human health and the environment (Manhart et al. 2014b). In this situation, it is obvious that voluntary bring-systems – such as those in EU countries – are prone to failure because they are significantly less convenient for households and businesses and also do not involve any monetary incentives. Although informal collection systems tied to informal recycling dominate the e-waste collection in Ghana, to-date, there are first initiatives to reorganize collection so that e-waste is flowing into formalized and environmentally sound recycling systems:

In 2013, City Waste Recycling Ltd. opened an e-waste collection point in the city of Ho (Volta Region). It is – to date – the only formal e-waste initiative that is not limited to particular types of devices such as mobile phones or fridges. For the future it is planned to install comparable collection points in all major cities in Ghana (Accra, Tema and regional capitals). For the first collection point, Ho was chosen mainly because the City Waste Group[23] had already run a collection point for plastic waste in this location prior to 2013. In addition, Ho is not yet targeted by informal scrap metal collectors and recyclers so that competition is less fierce compared to other urban areas in Ghana. The collection point consists of one 20-feet container that is located on a municipal site within the city of Ho. A signboard that is well-visible from the roadside indicates opening hours. Persons bringing e-waste to the collection point are paid cash-money by an employee of the City Waste Group. The amount paid depends on the weight and type of equipment and refers to a price-list that defines purchasing prices. The price-list is updated every month in order to adjust to fluctuating scrap metal prices. Table 3-1 gives some examples for purchasing prices as of May 2014.

[23] The City Waste Group comprises the companies City Waste Management (plastics and saw-dust recycling) and City Waste Recycling (e-waste recycling).

Table 3-1: Selected e-waste purchasing prices at the City Waste Recycling collection point in Ho (Ghana) in May 2014

Item	Price (GHS)	Price (US$)[24]	Measurement
PC System	0.60	0.20	kg
Hard Disk Drive	2.00	0.66	kg
Keyboard / mouse	0.07	0.02	kg
E-waste housings	0.02	0.01	kg
Wires and cables	1.30	0.43	kg

Source: City Waste Recycling Ltd. 2014

Collected e-waste is picked up by a truck and transported to the e-waste recycling facility operated by City Waste Recycling Ltd. in Accra.

E-waste can be handed in without prior registration.[25] This strategy takes into account socio-economic diversity as well as the various individual disposal strategies. Therefore, it is up to the households and businesses to decide whether they want to carry their e-waste to the collection point to get the full payment, or to use the service of (informal) waste collectors. In addition, such a structure can motivate individuals to sort out e-waste from the existing municipal solid waste stream.

[24] The collection point only pays in New Ghanaian Cidis (GHS). The US$ figures are calculated on the basis of the average collection rate in May 2014 (1GHS = 0.3311 US$)

[25] The only registration that is carried out are the receipts, which are written during the hand-over process and given to both, seller and buyer of e-waste. These receipts contain the types and weights of delivered e-waste, the paid sum, and the name of the seller.

Figure 3-1: E-waste collection point of the City Waste Group in Ho, Ghana.

Source: Öko-Institut e.V. 2014

There are three other initiatives in e-waste collection in Ghana, which are all focused on one particular product group: Two initiatives address the collection of mobile phones. While one is organized by the Amsterdam based organization "*Closing the Loop"* that offers cash for end-of-life mobile phones, the other is initiated by *Nokia* and carried out by City Waste Recycling Ltd. It aims at collecting end-of-life mobile phones and parts of mobile phones from repair shops. Both initiatives are based on external CSR-type (Corporate Social Responsibility) funding and work with distinct incentives: While the *close-the-loop* collection receives financing from *Fairphone*[26] that enables offering above-average prices for end-of-life mobile phones, the *Nokia* initiative gives out a limited number of new smart phones for persons and organizations collecting most mobile phones (Manhart et al. 2014b).

Another collection system in Ghana specifically addresses end-of-life refrigerators. It is tied to a new-for-old rebate program that plans to replace 50,000 functioning fridges for new and energy-efficient new devices within three years. Thus, the primary motivation is to take old and inefficient devices out of use to reduce domestic electricity consumption. The old fridges are given to City

[26] FairPhone is a Dutch start-up company that sells smartphones that were produced and designed according to the best social and environmental standards. For each sold smartphone, the company donates 3 Euros to finance projects on collection and recycling of end-of-life mobile phones.

Waste Recycling Ltd. for degassing and recycling. The project is organized by the *Ghana Energy Commission* and financed with funds from UNDP (Manhart et al. 2014b).

Regarding the expansion of these initiatives to all over Ghana, it has to be considered that formal recyclers such as City Waste Recycling Ltd. have to cover costs to manage negative-value fractions such as CRT-glass. As informal recyclers typically dispose negative-value fractions without any cost, they have an economic advantage over environmentally sound collection and recycling systems. There are only two principle ways to tackle this situation: strict regulations and enforcement requiring stringent monitoring and control of the system by competent authorities, or, the most promising way in most developing countries, overcome this disadvantage with additional funding to incentivize at least collection and possibly proper recycling (also see chapter 4.4). While the collection initiative on mobile phones and fridges managed to secure funding from international stakeholders, it should be considered that such international funds are typically limited in scope and time. In Ghana, it is planned to introduce an Extended Producer Responsibility (EPR) scheme that will raise an “e-waste levy” on all EEE brought onto the Ghanaian market (Manhart et al. forthcoming). Presupposing this levy will be used to finance environmentally sound management, it might help to make formal incentive based collection systems competitive.

Today, however, there is no legislative framework regarding e-waste in Ghana yet. There is a draft law that has not yet entered into force.

4. Considerations for an e-waste collection system in Ethiopia

Taking into account the findings from chapter 2 and 3, the following considerations for an e-waste collection system in Ethiopia can be made.

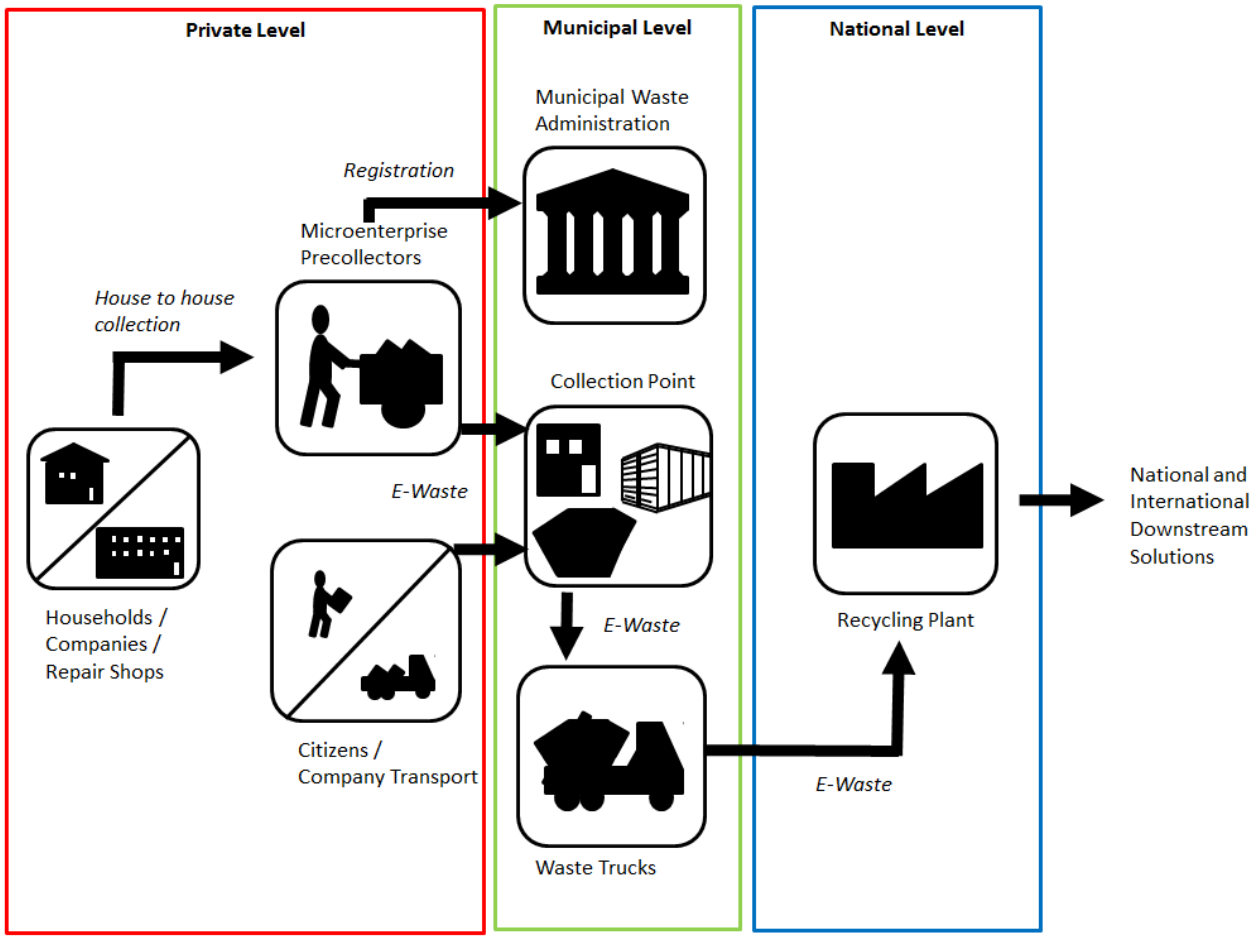
4.1. Organisational set-up

In Ethiopia, solid waste collection is successfully organized on the municipal level. This includes the registration of private pre-collection enterprises, the establishment of financing mechanisms, as well as the management of defined waste collection points where collected solid waste is handed over and enters municipal management systems. In order to avoid competing systems, it is recommended to integrate e-waste collection into these existing structures.

According to this model, it would be the responsibility of the cities' administrations to establish and run e-waste collection systems.[27] As already practiced in municipal solid waste collection, defined hand-over points could serve as key element of any municipal e-waste collection system and act as a link between private initiatives and municipal waste management tasks.

[27] For a detailed organisational set up see chapter 5.

Figure 4-1: Flow chart of the proposed e-waste collection system



Source: Own illustration.

Generally, it should be considered that every person and organization including informal collectors and collection enterprises is allowed to deliver e-waste to such hand-over (collection) points. Such a measure would enable all current stakeholders – private households, repair shops, registered pre-collectors and informal collectors – to integrate into such a system, either by delivering e-waste directly to a hand-over point, or by giving e-waste to formal or informal collectors or repair shops.

4.2. Collection infrastructure

It is recommended that collection infrastructure is developed in all major Ethiopian cities. In particular, Addis Ababa as well as the so-called *secondary cities* should be covered by collection systems. As illustrated in Table 4-1, secondary cities are characterized by populations between around 150,000 to above 250,000 people. Cities of around 150,000 inhabitants are likely to require one or two such e-waste hand-over points.[28] For Addis Ababa, each sub-city might require an own e-waste hand-over point, which would result in a total number of ten e-waste hand-over points.[29]

[28] This estimate is based on insights from the solid waste sector in various cities (see chapter 2).

[29] More information on hand-over points is provided in chapters 3.2 and 5.

Table 4-1: Major cities in Ethiopia

Rank	Name	Estimated population for 1 July 2012	Region
1	Addis Ababa	3,040,740	Addis Ababa
2	Mekele	273,601	Tigray
3	Adama	271,562	Oromia
4	Dire Dawa	262,884	Dire Dawa
5	Gondar	254,450	Amhara
6	Hawassa	212,665	SNNPR
7	Bahir Dar	191,015	Amhara
8	Jimma	149,166	Oromia
9	Dessie	147,592	Amhara
10	Jigjiga	147,482	Somali

Source: Manhart et al. 2013

Regarding the design of e-waste hand-over points, the following criteria should be taken into account:

- The hand-over point should provide enough storage space for collected e-waste. Ideally, the hand-over points should be able to accumulate e-waste for one full truckload.
- The storage area should be sheltered against rainfall and direct sunlight.
- Storage of devices and components that can pose direct health threats to people (e.g. gas discharge lamps, toner cartridges) should be organized in a way that they do not pose any health and safety threat to municipal employees or any other person (e.g. by storage on impermeable floor and sheltered from rainfall and direct sunlight)[30].
- Collection and storage space should be protected against theft of e-waste.
- Hand-over points should be clearly visible as such and adhere to defined opening hours.
- The population should be informed on the hand-over point (e.g. via leaflets)
- At opening hours, hand-over points should be manned with one (municipal) employee to register incoming e-waste.
- The municipal employee should get a basic training on handling with e-waste (especially on security issues).

To date, it is quite difficult to estimate incoming e-waste volumes that have to be handled by future collection systems. Nevertheless, the e-waste stocks in secondary cities such as Bahir Dar, Dire Dawa and Hawassa have been assessed to be in a range between 100 and 300 metric tons (see Table 4-2).

[30] The European Standard on Collection, logistics & Treatment requirements for WEEE – Part 1: General treatment requirements (EN 50625-1) require that collected WEEE shall be stored on impermeable surface and be protected by weatherproof covering.

Table 4-2: Estimated stock of non-functional equipment in three selected cities in 2011

	Personal Computers	TVs	Mobile Phones	Refrigerators	Total
Bahir Dar	147,000 kg	15,800 kg	90 kg	6,800 kg	169,690 kg
Dire Dawa	196,000 kg	41,600 kg	300 kg	62,000 kg	299,900 kg
Hawassa	85,200 kg	11,500 kg	60 kg	10,600 kg	107,360 kg

Source: Manhart et al. 2013

Assuming that a well-designed collection system can bring-in between 20 % – 60 % of this volume annually[31], this would result in annual collection volume ranging from 20 t to 240 t per secondary city. For Addis Ababa, no data for e-waste stocks and generation exist so that no predictions can be made on potential collection volumes.

In any case, it is recommended to start with introducing flexible structures for e-waste hand-over points. As illustrated in Figure 3-1 (chapter 3) taken in Ghana, sea-containers could be used in an initial phase of e-waste collection. The advantage of sea-containers is the fact that they are readily available at low price so that size and number of containers can be varied after first experiences in incoming volumes have been made. In addition, trucks for further transport of e-waste to recycling facilities (e.g. the DMF in Akaki) could be hired as long as incoming e-waste volumes are unstable and unpredictable.

4.3. Incentives

The field studies in the Ethiopian cities revealed that the current flow of e-waste from private households and businesses is widely steered by monetary incentives, which result from (1) the reuse value of devices and its parts, (2) the material value of individual fractions such as steel, copper and aluminum, (3) the volumetric value of residues (in Addis Ababa only)[32]. In order to organize e-waste collection from private households and businesses, these monetary realities need to be taken into account. In particular, it is advised to introduce new monetary incentives to steer e-waste towards designated hand-over points.

The latter issue is also supported by the analysis of the collection system in Ghana. It is expected that an e-waste collection system without payment for delivered e-waste from households and small and medium size enterprises is prone to failure. An exemption is e-waste from government offices where deregistration and disposal policies can secure a sound end-of-life management. Regarding e-waste from large enterprises, the situation is less clear: While on the one side, large enterprises can be more easily monitored compared to households and small and medium size

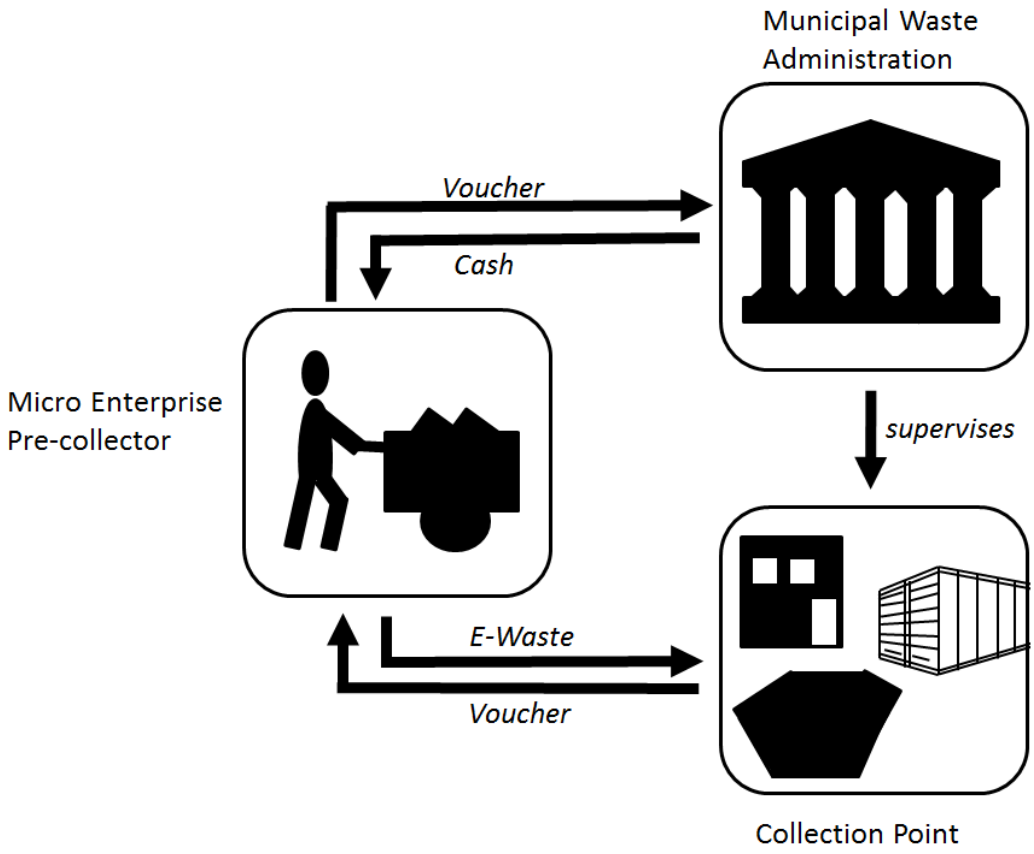
[31] It has to be taken into account that figures of Table 4-2 represent stocks that built-up over several years. Thus, annual e-waste generation is likely to be below these volumes. On the other side, the figures do not include other types of e-waste apart from PCs, TVs, mobile phones and refrigerators.

[32] As laid-out in chapter 2.2, pre-collector enterprises are remunerated on the basis of the collected waste volume. This system leads to an economic motivation to collect all types of waste without considerable material value, and to bring it into the municipal waste management system.

enterprises, financial incentives might also be considered for such entities[33]. Finally, it is a political decision which entities shall be covered.

In specific, it is recommended that municipal e-waste hand-over points register the delivered e-waste together with the identity of the delivering person. Based on this information, the delivering person will receive a receipt that can be cashed at a defined municipal government office[34]. Such a design widely follows the existing household waste collection structure already established in Addis Ababa (see chapter 2.2.1).

Figure 4-2: E-waste collection mechanism including monetary incentives



Source: Own illustration.

The level of monetary incentives needs to be defined carefully as it largely influences the type of devices and fractions that will be channeled into the e-waste collection system. Generally, it is advised that the level of incentives should be below the reuse value of devices, because e-waste collection and recycling should not compete with repair operations[35]. On the other side, incentives should be above the volumetric value of 50 Birr per m^3 to make sure that all e-waste is effectively

[33] While the ability for monitoring reduces the need for monetary incentives, an exclusion of large enterprises from incentive-based collection systems might also cause problems. As an example, such a measure could lead to a situation in which large enterprises tender their e-waste to intermediaries, who in turn sell it to the established e-waste handover points.

[34] Such a system could on the one-side build on existing municipal waste management structures, on the other side it would reduce the security risks at hand-over points (no cash availability required).

[35] This is in line with the general waste hierarchy that gives reuse activities priority over recycling.

separated from municipal solid waste.[36] For e-waste fractions containing valuable metals, incentives should reflect these values and make sure that they can compete with the price levels offered by the Ethiopian scrap market.

Additionally, incentives should take into account quality aspects for devices containing hazardous materials or components. By paying a premium for non-broken gas discharge lamps (CFLs) as well as CRT-tubes, households and collectors can be motivated to carefully manage end-of-life devices in order to avoid emissions of hazardous substances. Furthermore, it is advised to take other quality aspects into account.

This includes:

- Cables should only be accepted with insulation to discourage unsound practices such as open cable burning;
- Although incentives should be paid for dismantled devices (to consider the e-waste from repair shops), the incentive structure should be set in a way that they do not additionally encourage dismantling (slightly higher prices for non-dismantled devices);

Further considerations on a possible incentive structure can be found in chapter 5.

[36] 50 Birr per m3 is the typical price waste collectors are paid for the collection of solid waste.

4.4. Financing e-waste collection

As laid out in chapter 4.1 - 4.3, successful e-waste collection from households and businesses needs to be economically attractive for the collectors and acceptable for the households. As a formalized and environmentally sound e-waste recycling will have to carry costs to properly manage hazardous and other fractions with a negative or no economic value, they would – without market intervention – be structurally put at disadvantage compared to recyclers that do not carry any expenses for the management of hazardous waste. Therefore, a collection system that is exclusively financed by the material value obtained in environmentally sound recycling operations will not be successful in an unregulated market.

This can be illustrated by Table 4-3 that displays the cost structure of the recycling of one CRT-TV. Although the calculation was done for the recycling market of Ghana, it proves that recyclers only selling valuable fractions, without caring for the hazardous CRT-glass, earn significantly more money from their recycling activities. This matches the current situation in Ethiopia, where repair shops or other players sell valuable fractions to the highest bidding scrap metal dealers. It is obvious that – under such conditions – environmentally sound recyclers cannot successfully compete in the e-waste collection from private households and businesses.

Table 4-3: Monetary return for formal and informal recyclers from recycling of one CRT-TV in Ghana

Fraction	Weight [g]	Value [US$/kg]	Transport costs [US$/t]	Net-value formal recycler [US$]	Net-value informal recycler [US$]
CRT-glass	11,884	-0.1	154	-3.02	0
Copper	1,995	5	142	9.69	9.69
Steel	378	0.3	13[37]	0.11	0.11
PWBs	3,461	0.26	142	0.16	0.16
Sum				**6.94**	**9.96**

Source: Manhart et al. 2014a

It is therefore required to access additional means of financing to bridge these structural problems in e-waste collection and management. Globally, the principle of Extended Producers Responsibility (EPR) was developed to cover the cost for environmentally sound management of e-waste by introducing a form of the polluters-pay-principle. Mostly, this EPR approach is interpreted in a way that actors bringing new or used electrical and electronic equipment onto the market are held responsible for the environmentally sound management of an equivalent amount of e-waste. While some EPR-schemes raise funds from importers to cross-finance collection,

[37] The low value for transport costs for steel is due to the fact that steel is recycled on the domestic market.

logistics and recycling activities, others allow producers and importers to build up own collection and recycling systems to fulfil their e-waste management tasks.

With a view to the situation in Ethiopia, an obvious difficulty is the fact that a significant share of EEE is smuggled into the country to evade import taxation, mostly via the border with Somalia (see chapter 2.5). In such a situation, an EPR-system that addresses importers has to deal with the following difficulties:

- Many importers and their import volumes are not registered, which makes it difficult or even impossible to introduce a comprehensive and fair EPR-system. Registered importers would be charged with e-waste management financing, while non-registered importers would not be covered by such charges. Such inequalities would of course distort the market.
- Additional financial or non-financial burdens resulting from EPR will further increase the incentive for smuggling.

Taking these problems into account and also considering the fact that municipalities are already successfully organizing financing systems for household solid waste collection (see chapter 2), it should be considered to introduce an EPR-system that sources its funds on the municipal level. In particular, funds to finance e-waste collection (and possibly also transport and recycling) could be raised from shops selling new or used electrical and electronic products. As these shops are registered with and controlled by the municipality, EPR-funds could be raised on the basis of the municipal income tax (by adding a certain EPR-percentage).

Another option would be to raise e-waste management funds together with the electricity bill (by adding a certain percentage to the electricity bill). While this model has the advantage that the level of fee would correlate with electricity use and therefore most likely also with the individual use of electrical and electronic equipment, it has some other issues to consider:

- Such a system would directly charge all businesses and private households (consumers) and would therefore fall out of the usual definition of “Extended Producer Responsibility”.
- As most urban households and businesses already pay for municipal waste collection, additional waste related fees might be difficult to justify.

The following Table 4-4 summarizes the strengths and challenges of the potential types of EPR- and other models to finance e-waste collection and management in Ethiopia.

Table 4-4: Strengths and challenges of three potential types of ERP-models to finance e-waste collection and management in Ethiopia

Model	Strengths	Challenges
Federal government EPR for producers and importers	• In-line with many EPR-systems of other world regions (polluters-pay-principle).	• Expected difficulties to register all importers. • Additional incentives for smuggling. • Requires redistribution of federal funds to municipal waste collection systems.
Municipal EPR for shops selling EEE	• In-line with general EPR-concept (polluters-pay-principle). • Shops selling EEE are already registered with the municipalities. • No redistribution of funds from federal to municipal level required.	• System would need to be developed individually in all major urban areas.
E-waste management funds raised with electricity bill	• Level of fee would correlate with the use of electrical and electronic equipment.	• Ethiopian legislation already goes for EPR (for this reason such a system would not be viable) • System would add a second waste management charge onto households and businesses.

Source: Own survey.

5. Pilot collection system in Addis Ababa

As pointed out in chapter 4.1, the municipality is believed to be the suitable administrative level to organize e-waste collection. In the case of Addis Ababa, it should be considered to establish a pilot collection point on the Woreda level (third administrative level). The research team has already identified and visited a collection point for solid waste in Woreda 1 (Bole Sub-city) that could possibly be chosen for pilot implementation. There, solid waste collection microenterprises (pre-collectors) already work on the basis of a longtime cooperation with the municipal authorities.

Alternatively, collection could be tested in the Merkato area. There, competition over used devices as well as scrap metals is believed to be highest, which means that quite high monetary Incentives would have to be offered to compete with the informal scrap metal dealers. However, in case the price structure is successful there, it is very likely that it is also applicable all over Ethiopia. Compared to the Merkato area, competition over scrap metals is believed to be less fierce.

5.1. The setup of an incentive structure

As a starting point of the pilot e-waste collection system, it is recommended to incentivize households, Quorales and repair shops in order to raise the willingness to hand over end-of-life electric and electronic equipment (see chapter 4.3). Therefore, the project team proposes a monetary incentive structure in-line with the following principles:

- Monetary incentives should be based on the prices paid in the informal sectors for entire devices, components and materials thereof (see Table 2-1). The prices could be updated on a regular base to reflect the price changes of the valuable materials on the national and, where collectors have access, the international metal markets.
- For valuable materials, steel, aluminum, copper and high grade printed wiring boards (mainly gold) should be considered in the calculation of prices (see below). These materials represent the main value-carriers of most e-waste fractions[38]. While there is a developed steel scrap market in Ethiopia, also aluminum and copper find markets that are most likely linked to foreign markets (export). Furthermore, observations in Merkato Market (Addis Ababa) suggest that the trade of high grade printed wiring boards is developing (see chapter 2.2).
- The prices for the steel, aluminum, copper and printed wiring boards in e-waste and components thereof should be above the price levels within Ethiopia, and below the international price levels in order to avoid the influx of e-waste from other countries overcharging the Ethiopian system.
- People bringing e-waste to a handover-point should be compensated on the basis of the type of e-waste and its weight. Thus, a pricelist needs to be established that specifies kilogram-prices for the various product groups.
- The pricelist needs to be updated regularly in order to reflect changes in the local and world-market prices for metals.[39]

[38] Some products such as uninterruptible power supplies (UPS) also contain other value carriers such as the lead in the battery.

[39] On the one side, this is necessary to reduce the economic risk resulting from falling metal prices. On the other side, also rising prices have to be reflected in the price-structure as otherwise the price-structure might soon be topped by informal competitors.

- In order to discourage dismantling, prices for non-dismantled e-waste should be higher compared to those for dismantled e-waste, but lower than the prices repair shops pay for such devices in order to protect the repair and reuse culture in Ethiopia. Nevertheless, dismantled e-waste should also be accepted on the basis of kilogram-prices in order to provide attractive disposal options for repair shops.
- A baseline-price should be established for dismantled and unidentifiable e-waste. This price should be above the volumetric value of solid waste, which is currently 50 Birr per m^3 in Addis Ababa (see chapter 2.2).
- For some fractions, a premium should be paid that is related to quality aspects to avoid emissions of hazardous substances. Such premiums should apply to non-broken gas discharge lamps (CFLs) as well as CRT-tubes.
- Cables should only be accepted as part of devices or – if brought separately – with insulation. This is to avoid the practice of cable burning to retrieve copper.

The following chapters derive a suggested price structure that is based on these principles.

5.1.1. Baseline price for dismantled and unidentifiable e-waste

As indicated above the baseline price should be above 50 Birr per m^3 in order to motivate separation of e-waste, including non- and low-value devices and fractions such as cassettes, DVDs, landline telephones, e-waste plastics and CRT-tubes (without copper). As this fraction is likely to be widely free from (valuable) metals, it can be assumed that it has a quite low weight per volume, roughly equaling the specific weight of non-compressed plastic cases mixed with some assemblies such as low grade printed wiring boards. It is assumed that this fraction has a specific weight of ~250 kg/m^3. Thus, in order to top the volumetric value, the kg-price needs to be above 0.2 Birr/kg. As a starting point, it is suggested to use a kg-price between 0.3-0.6 Birr/kg, which can be increased in case of unsatisfactory collection results.

5.1.2. Prices for non-dismantled e-waste

It is recommended to use the following calculation formula for the price structure for non-dismantled end-of-life devices

Equation 5-1: Calculation of the price for non-dismantled EoL EEE

$$P_{device} = (m_{steel}\bar{P}_{steel}) + (m_{aluminum}\bar{P}_{aluminum}) + (m_{copper}\bar{P}_{copper}) + (m_{PWB}\bar{P}_{PWB}) \pm \varepsilon$$

Whereas:

$P = Price;\ \bar{P} = adjusted\ scrap\ metal\ price;\ m =$
$mass\ content\ of\ metal\ in\ device;\quad PWB = Printed\ Wiring\ Boards$
$\varepsilon =$ extra premium/charge for (un)dismanteled devices (occasionally)

The price incentive is basically composed of the sum of the values of the metal contents, such as $(m_{metal}\bar{P}_{metal})$, of the device. It is noteworthy, that for printed wiring boards, only high-grade boards from electronic devices should be considered in the calculation because medium- and low-grade boards have significantly lower concentrations of precious metals. While the observations in Merkato Market solely point towards existing trade of high-grade boards, it is also known from West-African countries that medium- and low-grade boards are mostly neglected by informal

recycling structures due to its unfavorable value per weight ratio. Typically, high grade printed wiring boards can be easily identified on the basis of their green board color. For this reason, high-grade printed wiring boards are often called “green panel” in some African countries such as Nigeria (Manhart et al. 2011).[40]

Furthermore, the assumed metal price level ($\bar{P}$) has to be adjusted to the needs of the pilot e-waste collection system. It has to top Ethiopian scrap metal market prices to avoid incentivizing dismantling by formal or informal collectors to realize arbitrage gains by selling the metals only (“cherry picking”).

The derivation of the adjusted scrap metal prices ($\bar{P}$)for the purpose of the pilot collection system takes into account the figures for the Ethiopian scrap market from field research in Merkato market from 27 October – 6 November 2014 (chapter 2.2.3). Also, world market prices for steel, aluminum, copper and high-grade PWBs (mainly due to gold) are taken into account. The ratio of local prices and world market prices is around 91% for steel, 31 % for aluminum, 36 % for copper and 3 % for high grade printed wiring boards (see Table 5-2).

Table 5-2: Comparison of Ethiopian scrap metal market prices and world market prices

	Market price Ethiopia[41], October 2014 [Birr/kg]	Market Price Ethiopia October 2014 [US$/kg]	World Market Price Q3/2014[42] [US$/kg]	Ratio Ethiopian price / world market price (a) [%]
Steel	8	0.41	0.45[43]	91%
Aluminum	12	0.61	1.73	31%
Copper	50	2.53	7.29	36%
High Grade PWB	4.5	0.23	7.05	3%

Source: Own survey, USGS 2014a, USGS 2014b, USGS 2014c, Cascade Assets 2014.

Accordingly, the project team proposes to use the derived scrap metal ratios “a“ of Ethiopian prices vs. world market prices for all considered value fractions. As world market prices as well as local prices for scrap metals fluctuate considerably over time, for the purpose of the pilot e-waste collection system, it is recommended to test the following proposed formula to calculate acquisition prices for EoL EEE and components.

$$\bar{P} = a\,\% \times (P_{world\,market})$$

Hence, by means of this formula, acquisition prices can be adopted regularly according to world market fluctuations of scrap metal components.

[40] The term “green panel” for high grade printed wiring boards (e.g. used in desktop-PCs, flat screen-TVs or mobile phones) refers to the fact that they are mostly use a green coloured board-matrix, whereas for medium and low grade boards red or brown colours are used.

[41] Data according to field research in Merkato Market, 27 October – 6 November 2014. It has to be highlighted that scrap metal prices fluctuate according to world market prices.

[42] Data is taken from the 3rd quarter of the year 2014 by USGS.

[43] Data for pig iron.

The pilot collection system should take into account all major types of e-waste and therefore has to come up with average material compositions of various types of product groups. It is recommended that the material compositions (total weight of device, content of steel, Al, Cu, high-grade PWBs) are assessed in dismantling trials in Ethiopia to reflect the typical characteristics of e-waste in Ethiopia. As an example these trials could be realized by the Demanufacturing Facility (DMF) in Akaki Kaliti. In the following, however, calculations are carried out according to literature data. Table 5-3 gives an impression of such a calculation according to material compositions of a desktop PC:

Table 5-3: Estimation of the price for an EoL desktop-PC for the pilot project

Total weight of a desktop computer	9738.72 g				
Valuable Materials	**Content of desktop PC**	**World Market Price [US$/kg]**	**World Market Price Correction(a)**	**Price per kg desktop PC [US$/kg]**	**Price per kg desktop PC [Birr/kg]**
Steel	69%	0.45	91%	0.28	5.52
Aluminum	6%	1.99	31%	0.04	0.72
Copper	4%	7.10	36%	0.10	2.00
High Grade PWB	9.30%[44]	7.05[45]	3%	0.42	
Total				**0.44**	**8.66**

Sources: Manhart et al. 2011; Gmünder 2007 ; Cascade Assets 2014.

Thus, according to this calculation a price of 8.66 Birr per kilogram is recommended for non-dismantled desktop PCs (without monitor and peripherals) according to scrap metal prices in October 2014. The field research in Merkato Market, Addis Ababa (see chapter 2.2.3) resulted in a price of at least 350 Birr repair shops pay for a dismantled desktop-PC. Assuming 10 kg for one desktop PC would result in a price of 87 Birr per desktop-PC. Hence, the collection system's price would be significantly lower than the repair shop's price. This is preferable as re-use and repair of EEE shall not be affected by the collection system. However, it has to be verified within the pilot collection system whether undismantled devices can be received in practice.

Similar calculations were carried out for CRT-TVs, CRT-monitors, refrigerators, washing machines and air conditioners, using the following material compositions (Table 5-4). Consequently, the calculated prices for EoL EEE are illustrated in Table 5-5.

[44] According to Gmünder 2007, p.51: Motherboard and other high grade PWBs

[45] Price information according to Cascade Assets 2014: 3.20 US$ per Pound.

Table 5-4: Average content of valuable material of selected devices

Device	Steel	Copper	Aluminum	High Grade PWB
CRT-Television	10%	3%	2%	-
CRT-Monitor	6%	5%	0.1%	-
Refrigerator	50%	4%	3%	-
Washing Machine	53%	4%	3%	-
Desktop PC	69%	6%	4%	9.3%
Hard Disc Drive [HDD], 3.5 inch	32%	1%	56%	8%
Hard Disc Drive (HDD], 2.5 inch	32%	1%	49%	8%

Sources: Metal contents of CRT-TVs, Refrigerators, Washing Machines and Air Conditioners according to CTI 2005;
Metal contents of a CRT-Monitor according to Lee 2002; Parson 2008; Wecycle 2009; HDD according to Gmünder 2007.

The material compositions illustrated in Table 5-4 are taken from the literature.

5.1.3. Premium prices for selected devices and fractions

Premium prices should be offered for the following devices that pose the risk of pollution if not properly managed during collection and transport:

- Unbroken CFLs: A price of 2 Birr/kg is suggested (4 times higher than the baseline-price). This estimation is not based on scrap metal prices but is only oriented at the price for dismantled and mixed e-waste. Therefore, a strong incentive to hand over unbroken (mercury containing) CFL-lamps is set.
- Cables with insulation: It is suggested to pay the full local copper price (which are the world-market price minus the applied market correction factor) for cables. Thus, collectors would get money for both, the copper and the non-valuable insulation.
- For CRT-devices full payment should only apply for devices with undamaged tube and including the copper-yoke. In case the tube is damaged, a price-deduction of 20% is recommended. A comparable strategy should apply for refrigerators and air-conditioners with regard to the cooling circuit.
- Furthermore, it should be considered to also accept pure fractions (such as steel, aluminum, copper and PWB), but only if it is verified that it comes from e-waste. For these pure fractions also a discount of 20% is recommended. In order to prevent possible cable burning activities in the informal sector copper wires should only be accepted with insulation.

This system would result in a price list comparable to the one sketched in Table 5-5.

Table 5-5: Indicative price-list for pilot e-waste collection in Ethiopia

Device / fraction	Price	Comment
Dismantled & mixed e-waste	0.5 Birr / kg	
CFL-lamp	2 Birr / kg	Only non-broken CFLs. Broken CFLs are considered dismantled & mixed e-waste
CRT-Television	2.54 Birr/kg	Only non-dismantled with intact tube and including copper-yoke
CRT-Television [damaged tube]	2.03 Birr/kg	Non-dismantled with damaged tube
CRT-Monitor	2.85 Birr/kg	Only non-dismantled with intact tube and including copper-yoke
CRT-Monitor [damaged tube]	2.28 Birr/kg	Non-dismantled with damaged tube
Refrigerator	6.36 Birr/kg	Only non-dismantled and with undamaged cooling circuit
Refrigerator [damaged cooling circuit]	5.09 Birr/kg	Non-dismantled with damaged cooling circuit
Washing Machine	6.60 Birr/kg	Only non-dismantled
Desktop PC	8.66 Birr / kg	Only non-dismantled
Air Conditioner	13.74 Birr/kg	Only non-dismantled and with undamaged cooling circuit
Air Conditioner [damaged cooling circuit]	11 Birr/kg	Non-dismantled with damaged cooling circuit
Cables	50 Birr / kg	With insulation. Only small volumes should be accepted per transaction – to avoid motivating cable theft.
Hard Disc Drives (HDD), Standard 3.5 inch	10.33 Birr /kg	Standard Desktop PC HDD: 3.5 inch
Hard Disc Drives (HDD), Small	9.47 Birr / kg	Small HDD: 2.5 inch
High Grade PWBs	6.40 Birr/ kg	Boards are typically green.
Copper	40 Birr / kg	Only if verified from e-waste.
Aluminum	9.60 Birr / kg	Only if verified from e-waste.
Steel	6.40 Birr/kg	Only if verified from e-waste.

Sources: Metal contents of CRT-TVs, Refrigerators, Washing Machines and Air Conditioners according to CTI 2005; Metal contents of a CRT-Monitor according to Lee 2002; Parson 2008; Wecycle 2009.

It is recommended to extend the indicated-pricelist (Table 5-5) for other EoL devices such as radios, LCD-Televisions, LCD-Monitors, Uninterruptible Power Supplies (UPS) and other EEE. Finally, it is highlighted that the price list for the pilot e-waste collection has to be adopted according to changes in world market scrap metal prices and received e-waste volumes (e.g. in case the influx of e-waste is too low). In order to support the municipal waste agencies it is proposed that this is carried out by experts of the Federal Ministry of Environment and Forest (MEF) or the Public Procurement and Property Disposal Service (PPPDS). Updates of the pricelist

should be done at least monthly by using Equation 5-1 presented in chapter 5.1.2. More regular updates are needed during periods of significant and rapid commodity price changes.

5.2. Infrastructure and personpower

The pilot e-waste collection system requires infrastructure. Generally, the project team recommends renting containers and trucks. Due to the uncertain (and to a certain extent unpredictable) e-waste volumes the outline of the collection point should be held flexible with regard to installations. In addition, major and irreversible investments (e.g. into building structures) should be widely avoided until sufficient experiences have been collected regarding suitable dimensions.

Furthermore, it is recommended to use an existing collection point for solid waste as centrepiece of the pilot e-waste collection system as formal and possibly informal collectors frequent these places anyway.Therefore, the collection point needs an extension of the existing infrastructure with regard to the following points:

- one additional employee responsible for the receipt of EoL electric and electronic devices according to a predefined list,
- one lockable ISO 20 ft container (TEU[46]) for the storage of received EoL electric and electronic equipment,
- an enclosed location (fence, lock) for the location of the container, best on the ground of the solid waste collection point,
- office equipment (desk, chair, receipt book etc.) for the employee that allows for the establishment of a workplace in front or the container,
- one balance to weigh the devices/components.

In the municipal waste administration the following preparations should be made:

- one desk officer who shall be responsible for the pilot e-waste collection system,
- this person is authorized:
  - to accept the vouchers that are emitted by the collection point for EoL devices and
  - to pay off for the vouchers (cash),
- a supervisor for the desk officer.

A weekly comparison of the paid off vouchers and received devices at the collection point shall be carried out between the administration and the collection point.

Furthermore, a truck has to be rented, that allows for the transport of the full e-waste collection container from the collection point to the Demanufacturing Facility in Akaki.

5.3. Cost considerations for a pilot e-waste collection system

For the preparation of the pilot e-waste collection system a detailed cost structure is provided in this chapter. The illustrated capacities are calculated according to the following assumptions:

[46] Twenty-foot Equivalent Unit.

- For the sake of simplification, in the following it is assumed that the collection point shall clear 100 t of e-waste in the first year. This translates into 8.3 t per month.
- A 20 ft container can be loaded with 5 to10 t of non-dismantled e-waste, depending on density of devices and packing.
- Taken this into account, to clear 8.3 t per month one 20 ft container is needed.[47]

The project team highlights that the assumed capacities can only be a rough estimate. Consequently, further capacities shall be kept flexible, e.g. for the case the real volumes exceed the estimated ones. Therefore, the pilot collection system should rather be based on the rent of infrastructure than on expensive investment in equipment that might not be suitable for the e-waste collection system at a later stage.

Based on indicative prices the following Table 5-6 provides an overview of the investment costs of a pilot collection system. However, possibly existing office equipment can be granted by the municipality.

Table 5-6: Investment costs of an pilot e-waste collection system

Financial Positions	Estimated Costs [Birr]	Total [Birr]
Investment Cost		
Office equipment for the collection point (Furniture etc.)	15,000	
Total Investment Cost		**15,000**

[47] The transport of a container requires that it is jacked up to allow a truck to load it. Either the container is jacked up at the time of loading during the collection already or it has to be cleared, jacked up and refilled before it is transported by a truck.

Accordingly, the monthly running costs of a pilot collection system are estimated according to indicative prices. They are illustrated in Table 5-7.

Table 5-7: Monthly running costs for a pilot e-waste collection system

Financial Positions	Estimated Costs [Birr]	Total [Birr]
Labour Cost		
1.5 Positions in administrative staff (desk officer + surveillance) (monthly wage)	7,500	
1 Employee at collection point (worker) (monthly wage)	5,000	
Total labour cost per month		12,500
Transportation Cost		
Monthly Rent for one 20ft container	15,000[48]	
Truck transport from collection point in Addis Ababa to Akaki Demanufacturing Facility	13,000[49]	
Average transportation costs for one transport per month		28,000
E-waste Acquisition Cost (Price Incentives)		
Finance of the purchase of 8.3[50] t of EoL devices per month (in the case of desktop PCs, refinanced by scrap metal sales)	71,878	
Total Running Cost per month (excl. E-waste Acquisition Costs)		**40,500**
Total Running Cost per month (incl. E-waste Acquisition Costs)		**112,378**

The e-waste acquisition costs (price incentive) are integrated as they accrue at the collection point. However, these costs can be (partly) compensated by the sales of scrap metal fractions retrieved from the collected e-waste in recycling enterprises such as the DMF.

48 In case a 40ft container is chosen, the monthly rent of one container is 20,000 Birr.

49 This price includes all costs of a transportation service as offered by a private company such as personal costs, gas online and vehicle costs. The prices are the result of a local price survey.

50 The amount of 8.3 t of EoL devices per month is derived above in chapter 5.3.

6. Summary and Recommendations

The research and field studies in Addis Ababa, Dire Dawa, Hawassa and Jigjiga carried out within the scope of this project yielded the following findings:

- All surveyed municipalities have an established system to collect solid waste from households and businesses. It is mostly based on registered pre-collection enterprises (often referred to as *associations*) that are remunerated on the bases of their collection service (either on a volume base or in line with a defined monthly payment). In Dire Dawa, Hawassa and Jigjiga, households are free to join the system or to organize their waste disposal independently.
- The financial flows are exclusively organized on a municipal level and do not interfere with any regional or federal procedure.
- Apart from the registered pre-collection enterprises, informal waste collectors frequent households and businesses to obtain valuable waste fractions (e.g. metal containing wastes, intact glass bottles). These informal collectors are known as *Quorales.*
- There are various initiatives to sort the collected municipal solid waste. Apart from such trials, individual pre-collectors and waste pickers on municipal waste disposal sites typically sort out valuable fractions on their own initiative (e.g. steel, aluminum, non-broken glass bottles, clean PET-bottles).
- While all surveyed cities have developed systems to collect municipal solid waste, e-waste collection is still in its infancy. The only existing e-waste collection system solely addresses e-waste from federal government offices and some NGOs and international organizations located in Addis Ababa. E-waste from households and businesses is not yet covered by any specific collection system.
- Currently, non-functioning electrical and electronic devices from households and businesses are either stored, sold to informal collectors (Quorales) or given to repair shops – either to restore functionality or to be used as source of spare parts. Small volumes might also be disposed via the municipal waste collection.
- Thus, e-waste is accumulating in repair shops, mostly in a dismantled form. Fractions not suitable for repairs are typically disposed with the municipal solid waste collection. Valuable fractions such as copper, aluminum and steel are typically sold to informal scrap collectors (Quorales).
- As informal collectors (Quorales) pay cash money for mixed or sorted scrap metal, they are linked to domestic or even international scrap markets. In particular in Addis Ababa, there are indications that also high-grade printed wiring boards (PWBs) are collected and sold for recycling. Thus, informal scrap metal collection and trading is developed in urban Ethiopia and already addresses metals retrieved from e-waste.
- While there is already an e-waste collection system for Federal Government Offices, region and city administration offices do not yet have any means or strategy to dispose e-waste. While some cities (e.g. Hawassa) tried to tender old office equipment in the past, most offices simply store old devices within their premises.
- Additionally, it is recommended that the collection efforts of e-waste from public offices of the PPPDS at the federal national are cascaded down to the regional level. On the regional level, no e-waste from public offices has been collected yet.

- In Jigjiga the solid waste management system is under revision. As five enterprises could not continue their business in 2013, three new enterprises were established now working in a trial stage in cooperation with the City Sanitation and Beautification Agency.
- Jigjiga is widely known for being a hub for illegal imports of EEE, which is mostly brought into the country via the close border to Somaliland. Smuggling is mostly motivated by the opportunity to save import taxes that range from 20% to 50% depending on the type of EEE. Electronic and electrical equipment is mostly sold in specific shops that are located in two special markets (Old Taiwan market; New Taiwan market) as well as shops distributed over the city. In total, there are around 300 shops selling EEE. Almost all of the sold EEE is new. Second-hand EEE has a very small market share.
- The ports of Somaliland and Djibouti are the main sources of smuggled EEE to Jigjiga. Despite government attempts to block the trade to Jigjiga and from Jigjiga to other Ethiopian cities, trade continues. This trade is conducted by individuals (who come to Jigjiga for small scale shopping) and by organized groups that maintain information networks and structures to bypass check-points.

Regarding e-waste collection systems in other countries, the following findings could be generated:

- E-waste collection in Ghana is characterized by informal collectors that buy e-waste from households and businesses. This system is known to be very efficient in terms of collection rate (~95%) but is not linked to any formal and environmentally sound recycling. Thus, it is part of a chain that is known to have severe impacts on human health and the environment.
- To solve this problem, alternative collection systems are currently developed in Ghana. While three of these systems focus on a very small product range (mobile phones and refrigerators), the collection system that is currently developed by City Waste Recycling Ltd. accepts all types of e-waste, both, in complete and dismantled form.
- Core of the collection system by City Waste Recycling Ltd. are collection points that pay cash money to everybody handing in obsolete EEE. The prices for e-waste are set on a weight basis and refer to a price-list that is updated monthly to reflect changes in scrap metal prices.
- Key challenge of e-waste collection systems in Ghana is financing. The three specific collection systems for mobile phones and refrigerators secured financing from international sources. While such financing can significantly facilitate collection, such approaches strongly depend on donors. Thus, it might not be able to maintain them over long time-periods or to expand them to other types of e-waste.
- The collection system by City Waste Recycling is currently exclusively financed via revenues generated from recycling operations. As City Waste Recycling Ltd. also carries the efforts and expenses to properly manage negative-value fractions such as CRT-glass, it has limited financial means to compete with collectors that are linked to informal recycling that do not properly manage negative-value fractions.
- Therefore, the future of e-waste collection in Ghana strongly relies on the development of a financing system that can bridge the structural economic disadvantages of formal and environmentally sound collectors and recyclers. Such financing mechanism is already under development by the Ghanaian authorities but not yet implemented. It refers to the principle of Extended Producer Responsibility and raised a defined “e-waste levy” on all EEE brought onto the Ghanaian market.
- In Germany, e-waste collection is based on the European WEEE-Directive and implemented within the Electrical and Electronic Equipment Act (ElektroG). It is based on the principle of Extended Producer Responsibility (EPR).

- Within the German EPR approach, the producers are responsible for an appropriate disposal of e-waste. This is possible by individual activities or collective approaches together with other companies.
- Producers are organized in collective schemes that are coordinated by a clearing house (Elektro-Altgeräte Register – EAR) or have individual contracts with disposal and logistics companies. The clearing house registers producers and monitors the market share of the producers and assigns the share of e-waste to be taken back by the producers respectively.
- As municipal authorities have to provide collection points, the system is characterized by "shared product responsibility". However, producers have to finance and organize the final disposal.
- End-consumers can deliver e-waste *free of charge* ("bring system") but have to bear the transportation cost to collection points (no collection at households). Collection rates, however, are below 50% in Germany (Deubzer 2011).

Based on these findings, the project team laid-out various considerations for an e-waste collection system in Ethiopia:

- As solid waste collection is currently managed on a municipal level in Ethiopia, it should be considered integrating e-waste collection into these existing municipal structures.
- In particular, it is recommended to establish e-waste hand-over points in urban centers that accept e-waste brought by various stakeholders such as households, businesses and formal and informal collectors.
- These hand-over points should provide enough storage space for at least one truckload of e-waste. In addition, the storage space should have an impermeable floor and be protected against rainfall and direct sunlight. The space should be lockable to prevent theft.
- Hand-over points should be clearly marked as such and adhere to defined opening hours, during which a municipal employee registers incoming e-waste. Also, it is recommended to locate them on or at least close to existing solid waste hand over points.
- As most e-waste types contain metals that already find a market in most parts of urban Ethiopia, it is expected that an e-waste collection system that does not offer any payment for delivered e-waste from households and small and medium size enterprises, is prone to failure. Therefore, it is recommended to establish an incentive mechanism for delivered e-waste that is based on monetary payments.
- An exemption is e-waste from government offices where deregistration and disposal policies can secure a sound end-of-life management.
- The question whether large enterprises should also be part of an incentive based collection system requires a political decision, taking into account the strengths and weaknesses sketched in chapter 4.3.
- The level of payment should be below the reuse value of devices and above the volumetric value of 50 Birr per m^3. For e-waste fractions containing valuable metals, incentives should reflect these values and make sure that they can compete with the price levels offered by the Ethiopian scrap market.
- Additionally, incentives should take into account that some devices may cause severe environmental and health impacts if handled and treated improperly. By paying a premium for selected non-broken devices and fractions such as gas discharge lamps (CFLs) as well as CRT-tubes etc., careful management of these end-of-life devices should be motivated to avoid emissions of hazardous substances.

- Cables should only be accepted with insulation to discourage unsound practices such as open cable burning. Furthermore, the incentive structure should be set in a way that it does not encourage dismantling.

The analysis also revealed at various points that the success of an e-waste collection system will strongly depend on a financing mechanism to (over-)compensate the structural disadvantages of environmentally sound collection and recycling compared to informal management practices.

- The study suggests exploring various types of financing mechanisms that follow the principle of Extended Producer Responsibility (EPR). Globally, the EPR approach is interpreted in a way that actors bringing new or used electrical and electronic equipment onto the market are held responsible for the environmentally sound management of an equivalent amount of e-waste.
- While some EPR-schemes raise funds from importers to cross-finance collection and recycling activities, others allow producers and importers to build up own collection and recycling systems to fulfil their e-waste management tasks.
- Regarding the applicability of the various EPR-models in Ethiopia, it has to be considered that a significant share of EEE is smuggled into the country. For this reason, it might be difficult introducing a national EPR-system without causing further market distortion.
- As alternative to a national EPR-system, Ethiopia could consider an EPR-system that is designed and implemented on a municipal level. In specific, funds to finance e-waste collection (and possibly also transport and recycling) could be raised from shops selling new or used electrical and electronic products. As these shops are registered with and controlled by the municipality, EPR-funds could be raised on the basis of the municipal income tax.
- Another option would be to raise e-waste management funds together with the electricity bill (by adding a certain percentage to the electricity bill). While this model has the advantage that the level of fee would correlate with electricity use and therefore most likely also with the individual use of electrical and electronic equipment, it would directly charge all businesses and private households (consumers) and would therefore fall out of the usual definition of “Extended Producer Responsibility”.
- As each of the discussed options has characteristic strengths and challenges, which are summarized in Table 4-4, the choice and design of a financing mechanism is also a political decision. It is recommended that this decision will be taken in time in order to facilitate the development of an environmentally sound e-waste management system, and by taking into consideration the issues highlighted in this report. Otherwise, once an informal sector is firmly established dealing with e-waste it will be difficult to change the flows and prevent environmental and health damages, which can be observed in many developing countries and in countries with market economies in transition.

Regarding a pilot e-waste collection system for Addis Ababa, the project-team recommends the following:

- The municipality is considered to be the suitable administrative level to organize e-waste collection. In the case of Addis Ababa, it should be considered to establish a pilot collection point on the Woreda level (third administrative level). The research team has already identified and visited a collection point (also called hand-over point) for solid waste in Woreda 1 (Bole Sub-city) that might be able and willing to run a pilot e-waste collection system. Alternatively, collection could be tested in the Merkato area, which is believed to be the area with the highest competition over scrap metals.
- In order to incentivize households to hand over end-of-life electric and electronic equipment the project-team proposes monetary incentives based on valuable materials contained within the

devices (using average material compositions for all main product groups). An indicative price-list for the e-waste collection system is provided in chapter 5. However, the material compositions are taken from the literature and should be adopted by an assessment of typical e-waste characteristics in Ethiopia possibly by dismantling trials at the DMF.

- For valuable materials, steel, aluminum, copper and high grade printed wiring boards should be considered in the calculation of prices. The prices for the contained steel, aluminum, copper and printed wiring boards should be on average above the price levels within Ethiopia, and below the international price levels in order to avoid the influx of e-waste from other countries overcharging the Ethiopian system.
- People bringing e-waste to a handover-point should be compensated on the basis of the type of e-waste and its weight. Thus, a pricelist needs to be established that specifies kg-prices for the various product groups. The pricelist needs to be updated regularly in order to reflect changes in the world-market prices for metals[51].
- A baseline-price should be established for dismantled and unidentifiable e-waste. This price should be above the volumetric value of e-waste, which is currently 50 Birr per cubic meter in Addis Ababa. For some fractions (e.g. undamaged CFLs), a premium should be paid that is related to quality aspects to avoid emissions of hazardous substances.
- Infrastructure, manpower and costs for a pilot e-waste collection system are estimated in chapter 5 of this report. The cost estimations result in total running costs of 40,500 Birr excluding the monthly costs for the monetary incentives of e-waste collection. Including the estimated monthly costs for e-waste collection incentives, the total running costs would sum up to around 112,400 Birr.

[51] It is recommended that experts of the Ministry of Environment and Forestry or the PPPDs provide a regular update of the price list.

Summarizing, the project-team has the following key recommendations for decision-makers in Ethiopia as well as the E-waste Management Project in Ethiopia (EWAMP Ethiopia):

- **It should be considered to manage e-waste collection on a municipal level – in parallel to the established municipal solid waste collection systems.**
- **E-waste collection in Ethiopia should be supported by (financial) incentives.**
- **These incentives should be structured in a way that they motivate households, businesses and waste collectors to sort-out e-waste and to channel it towards dedicated hand-over points without causing any pollution.**
- **While collection- or hand-over points can be run and maintained by government agencies, there should be room for private stakeholders in the field of collection and transport to such hand-over points.**
- **A finance mechanism is needed to (over-)compensate the structural disadvantages of environmentally sound e-waste collection and recycling, compared with informal e-waste management.**
- **An additional mechanism should be based on the principle of Extended Producer Responsibility (EPR).**
- **While there are various possible options to introduce an EPR-based finance mechanism, a timely political decision is needed that takes into account the various considerations made in this report.**

In parallel, Ethiopia should work on a pilot scale e-waste collection to generate know-how and experiences for both, policy development as well as expansion to all urban centers in Ethiopia.

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