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Mission report :

Facility and process optimization

E-Waste Management Project in Ethiopia (EWaMP Ethiopia) funded by GEF

Thomas Poelmans, WorldLoop
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Report Commissioned by UNIDO
Final Report, 15/01/2015

The Federal Democratic Republic of Ethiopia
Ministry of Communication & Information Technology

Federal Democratic Republic of Ethiopia
Ministry of Environment and Forestry

CONTENT

A. EXECUTIVE SUMMARY

As part of its contract with UNIDO to provide technical assistance to the Akaki Demanufacturing Facility (DMF) in Ethiopia, WorldLoop performed a field mission aimed at preparing the DMF to scale up and upgrade their current operations. The output of the field mission consists of both concrete deliverables and a series of recommendations summarized below:

Objective 1: Review of the current dismantling & sorting process

Based on the process review, a few areas of improvement were identified with regard to the dismantling & sorting of e-waste, including depollution techniques, sorting fractions, best practices with regard to storage of output fractions and data registration.

We recommend to have an extensive hands-on training for DMF workers on depollution techniques, value maximization techniques as well as handling and storage guidelines for equipment containing hazardous material. Such training is currently planned to take place in Q2 2015.

Objective 2: Design a plant lay-out for the new DMF workshop

At the moment of the field visit, the construction works for a new workshop wear nearly completed. As an output of the field mission, we designed a plant lay-out for the new workshop taking into consideration the dimensions of the new workshop, space required for equipment & work stations, estimated capacity of the facility and the updated process flow.

Please refer to Annex 4a for a presentation of the new plant lay-out and Annex 4b for the technical drawings of the plant lay-out.

Objective 3: Provide a list with recommended equipment to upgrade the DMF

Based on a benchmarking with similar facilities and the available budget, a list with recommended equipment was made to upgrade the DMF in terms of processing capabilities and efficiency of treatment. An indicative budget was also developed to function as a reference for the public tender process. The equipment was categorized as "minimal required equipment" and "optional equipment" to allow flexibility in purchasing equipment depending on the available budget.

Please refer to Annex 5 for the list of proposed equipment.

Objective 4: Design an updated process flow for the DMF

Based on the current process and observations made during the process walkthrough (cfr. section F.1.), the updated plant lay-out (cfr. section F.2.) and the proposed list of equipment (cfr. section F.3.), an updated process flow was designed for the DMF.

Please refer to Annex 6 for the updated process flow.

Objective 5: Valorization & treatment of output fractions

As part of our objective to provide a way forward for the valorization and treatment of output fractions, we tried to obtain a correct and up-to-date inventory of collected assets and the current stock of output fractions and then estimated the approximate value of these materials.

As deliverables of the work done, please refer to Annex 7a for the inventory of collected assets and Annex 7b for the inventory of output fractions.

With regard to output fractions that cannot be treated locally, we summarized the applicable legislation and procedure to be followed and made a proposal with regard to organizing a first international shipmen. Moving forward, we recommend to initiate the procedure with regard to the sale of these fractions (requesting quotes, choice of supplier) and initiate the procedure for the export of the material as soon as the client (thus the country of import) is known.

Please refer to Annex 7c for the proposed composition of a first international shipment.

B. ACRONYMS AND DEFINITIONS

CRT	Cathode Tube Ray
CRTC	Computer Refurbishment and Training Center
DMF	Demanufacturing Facility
EWAMP	E-waste Management Project in Ethiopia
EC	European Commission
EU	European Union
FPD	Flat Panel Display
GEF	Global Environment Facility
HDD	Hard disk drive
IBLF	International business leaders' forum Business Leaders Forum
KERP	Kompetenzzentrum Eletronik and Umwelt
OECD	OrganizationOrganisation for Economic Co-operation and Development
PCB	Polychlorinated biphenyls
PPE	Personal protective equipment
PPM	Parts per million
PWB	Printed wiring board, also printed circuit board
UNIDO	United Nations Industrial Development Organization

C. BACKGROUND

The mandate of the United Nations Industrial Development Organization (UNIDO) is to promote and accelerate sustainable industrial development in developing countries and economies in transition.

In recent years, UNIDO has assumed an enhanced role in the global development agenda by focusing its activities on poverty reduction, inclusive globalization and environmental sustainability. UNIDO supports the development of e-waste recycling activities in developing countries, as part of its responsibility to promote sustainable industrial development in developing countries and in countries with economies in transition.

The objective of UNIDO's e-waste programme is to foster the development of an environmentally sound e-waste recycling industry in developing countries. With the active support of UNIDO's 35 National Cleaner Production Centres, UNIDO focuses on:

- Promoting an environmental service industry in developing countries
- Preparing national e-waste assessment reports
- Establishing partnerships with national and international institutions from the public and private sector
- Facilitating the establishment of local and regional e-waste dismantling and recycling facilities
- Supporting countries to develop effective legal frameworks and identify financing options to sustain the recycling system

UNIDO and the Ethiopian Government, with financial support from the Global Environmental Facility (GEF) have launched the E-waste Management Project in Ethiopia (EWaMP) in order to enable sustainable collection and treatment of e-waste. The project assists the Ethiopian Government to establish a national e-waste strategy (e-waste regulations, collection, financing training and awareness raising), upgrade the activities of the Demanufacturing Facility (DMF) in Akaki, Ethiopia and promote the cooperation with other countries in the region, and link the Ethiopian waste treatment facilities to national, regional and international markets.

D. *ABOUT THIS REPORT*

This report contains the findings and recommendations from the first field mission performed by WorldLoop in August 2014 as part of an engagement to provide technical assistance to the Akaki Demanufacturing Facility (DMF) in Ethiopia.

The objective of the ongoing engagement is to support UNIDO in up-scaling and upgrading the DMF in the following areas:

- Plant design and layout
- Process organization
- Assessment of equipment needs
- Optimization of output fraction valorization
- Provide regularly and on demand support to the ongoing works
- Provide a training for the workers of the DMF

E. *APPROACH*

The following approach was applied for the execution of the assignment:

1. Assignment preparation

- Document review
  - Review of relevant project documents
  - Review of relevant EWaMP Advisory Group documents
  - Review of EWaMP progress reports
  - Review of other project documentation (World Bank / IBLF project)

- Discovery interviews
  - Interview with UNIDO
  - Interview with World Bank / IBLF project managers
  - Interview with management of the DMF

- Work plan
  - Develop work plan for first field visit

2. Field visit 1: Review of current operations and needs assessment

The objective of the first field visit was to review the current operations ("as is") and benchmark them against a future situation ("to be") and establish recommendations for the way forward.

The field visit consisted of the following activities:

- **Process review**
  - Review of the current dismantling/sorting process and benchmark against common practices in other manual demanufacturing facilities
  - Formulate recommendations for efficiency improvements based on the current plant lay-out and process flow ("as is"-situation)

- Design a process flow for the future DMF operations
  taking into account a new plant organization (“to be”-situation)

- **DMF plant lay-out**
  - Examine the initial plant lay-out design,
    benchmark against “as is” and “to be” process flow
  - Calculate input, throughput and output capacity,
    as well as required working space
  - Design an updated plant lay-out for the future DMF operations in the new facility
    (under construction at the time of writing)

- **Equipment needs**
  - Assess equipment needs for the DMF
  - Identification of equipment type and existing suppliers
  - Prepare budget for facility equipment
  - Provide assistance with drafting tender documents

- **Valorization & treatment of output fractions**
  - Establish an up-to-date inventory of collection volumes (start of project – to date)
  - Establish an up-to-date inventory of output fractions (raw materials)
    for sale on the downstream market and/or further processing
  - Determine the approximate value of current supply of output fractions
  - Propose a consignment composition for the first international shipment
    of complex and hazardous fractions
  - Identify next steps to organize the first international shipment of complex and hazardous
    fractions

F. FINDINGS AND RECOMMENDATIONS

1. Review of the current dismantling and sorting process

Based on our process walkthrough of the current dismantling and sorting process at the DMF, a series of observations and recommendations were made ("as is"-situation).

i) Dismantling process

- **Depollution and value maximization techniques for PWBs**

Observation: Workers in the DMF workshop do not perform any targeted depollution (i.e. removing hazardous components) on printed wiring boards.

Please note that depollution of printed wiring boards is needed for printed wiring boards to be classified under the "green list" (i.e. non-hazardous waste) following the OECD guidelines and EU waste shipment regulation (see below.).

Depollution of PWBs implies the removal of hazardous parts such as:
- PCB (polychlorinated biphenyls) and PCT (polychlorinated triphenyls)
- mercury containing components
- beryllium containing components

In practice, these materials are found in large and heavy components without precious metals content such as transformers and large condensers. As a rule of thumb, one can say that for circuit boards coming from consumer IT (PCs, laptops, printers, copiers, DVDs, LCDs, servers ...) such components are usually not present. Hazardous components as mentioned above (PCB, mercury, Be) may however be present on boards from old IT equipment, or industrial or military IT equipment. For heavy low grade boards (power supply boards, TV boards...) the removal of large components such as transformers, condensers and capacitors should be ensured as well.[1]

Please also note that the net value of printed wiring boards can be significantly improved through the removal of aluminum and ferrous parts often found on mother boards, sound cards, video cards, etc. Although these metals have an intrinsic value, most precious metal smelters will not be able to recycle these them. Hence, non-removal of aluminum and ferrous metal parts will result in a net value loss after final processing. If removed, the volumes and weights of PWB decreases resulting in lower transport cost. Additionally, the removed aluminum and steel parts can be sold creating additional revenues.

Recommendation: Offer an extensive hands-on training to DMF workers on depollution techniques, value maximization techniques as well as handling and storage guidelines for equipment containing hazardous material.

[1] Please note that the classification of PWBs as "green listed waste" following depollution is based on the EU waste shipment regulation. Other interpretations may apply when shipping such material to regions outside of the EU.

- **Hesitance in handling equipment containing hazardous material**

Observation: In particular with regard to CRT and FPD monitors, workers at the DMF seem hesitant to handle CRT or FPD monitors due to limited knowledge on how to handle this equipment. They are not familiar with the hazardous substances inside (leaded glass, fluorescent powders, backlights) and the measures needed to ensure safe handling.

Recommendation: Offer an extensive hands-on training to DMF workers on depollution techniques, value maximization, handling techniques and storage guidelines for hazardous component containing equipment.

ii) Sorting process

- **Sorting of printed wiring boards**

Observation: One of the most valuable fractions, printed wiring boards, are currently not separated by grade[2] reflecting the precious metal content (e.g. low, medium, high grade) but stored all together in large Gaylord boxes.

Please note that sorting printed wiring boards by grade is a practice used by most pre-processing facilities. It enables accurately predicting the expected net value of these fractions and deciding the appropriate sales and processing channel.

This practice is even more useful once collection volumes allow to fill complete 20' or 40' containers of PWB. Indeed, an unbalanced mixed consignment (e.g. 2% high grade, 40% medium grade, 60% low grade) will result in considerable loss of value when sent to a smelter due to the margin of error in the sampling process. The dilution of precious metals and copper may reduce their concentrations below the minimum deduction threshold[3], which over proportionally decreases the prices paid per gram of these materials.

Recommendation: Sort the printed circuit boards per grade (low, medium, high) in order to make accurate predictions on the expected value and make well-informed decisions on the best way of selling the material (e.g. as one lot, sorted per grade).

Please refer to "Annex 1 – Sorting of PWBs" for visual guidance on grading and sorting of printed circuit boards.

- **Separating data connectors**

Observation: Data connectors (VGA, LPT, COM, PS/2, USB …) are not cut off but stored together with the rest of the cable.

Recommendation: Cut off data connectors from cables and store them separately. They contain precious metals and require a different treatment process (precious metal recycling) and will result in a higher value when marketed separately from the rest of the cable containing mostly PVC and copper. Data connectors can however be included in shipments to a precious metal smelter together with printed wiring boards and other precious metal containing material provided that the consignment has a balanced composition (see 'Sorting of printed wiring boards').

[2] In the industry, the following indicative values are common: low grade (0-100 ppm Au), medium grade (100-200 ppm Au), high grade (+200 ppm Au) and very high grade (+400 ppm Au).
[3] For more information, please refer to EWaMP report „International Downstream Markets".

iii) Storage process

- **Storage of most valuable items**

Observation: No specific measures are currently in place to prevent loss or theft of the most valuable items containing a high concentration of precious metals (e.g. processors, RAM memory) at the DMF.

Recommendation: Store the most valuable items in a large safe at the manager's office and move the processed materials from the workshop to the safe at the end of each working day to prevent loss or theft. These materials can be included in shipments going to a precious metal smelter provided that the contents of precious metals remains clearly above the minimum deduction threshold.

- **Consistent storage and labelling of output fractions**

Observation: We observed that identical output fractions are currently stored in different types of containers (small boxes, big boxes, drums) and kept in different places (on the ground, in a pallet rack, stacked on each other), without any label on the container. It is hard and time consuming to get an exhaustive overview of the total quantity of output fractions present in the workshop. Not all available containers (e.g. surplus of gaylord boxes) are currently being used.

Recommendation:
Store all output fractions in the container best corresponding to its destination (e.g. big bags for material to be exported, pallet box for materials to be sold locally) and the potential customers' requirements in a consistent place (e.g. pallet rack). Label all full containers indicating the type and weight of material inside. The containers selected should be in line with the packaging guidelines of the buyer of the materials.

Please refer to "Annex 2 – Recommended storage and packing" for common practices with to the type of packaging at the different process steps, as well as an estimate of the number of containers needed.

- **Full floor and half-empty pallet racks**

Observation: A considerable portion of the output fractions ready for export is being stored on the floor of the workshop area. As a result, the workshop floor is full while the pallet racks are empty. It is impossible to drive around with a fork lift and use the pallet racks to full capacity.

Recommendation:
Use pallet racks for all materials meant for export. When a container in the workshop is full, it should be moved into the pallet racks.

- **Use of Gaylord boxes**

Observation: The DMF keeps most materials meant for export in Gaylord boxes, which are expensive and difficult to stack in a sea container when exported.

Recommendation: Store all materials meant for export in big bags of (2x) 110 cm or (1x) 220 cm high.

iv) Data registration and monitoring

- **Input and output categories**

Observation: The categories currently used to register input and output material are not complete or mutually exhaustive. Some important fractions are not listed, and there are overlaps between categories.

Recommendation: Use established and clearly defined input and output categories for which mass balance data is available (e.g. UNIDO business planning tool) and don't adapt the list on case-by-case.

It is important to stress the importance of consistently using input and output categories. A consistent inventory of incoming material is **crucial** to be able to follow up on the evolution of collection results, both the *volume collected* and the *average value* of collected material. Keeping an up-to-date and accurate inventory of outgoing fractions is very important to make correct sales decisions taking into consideration available volumes, evolution of raw material prices, transport costs, etc. These decisions obviously have an important impact on the revenue generated.

Please refer to "Annex 3 – Updated input and output categories" for an updated list of categories for input and output material.

- **Introduce consistent weight registration throughout the process flow**

Observation: Incoming material is being registered per unit (PC, scanner, etc.) but not weighed upon arrival. Stock takings are weight-based but are done only occasionally and incompletely due to improper storage and labelling. Outgoing material is being weighed at the moment it leaves the facility.

Recommendation: Introduce consistent weight registration for all *incoming material* (at the moment of arrival), for all *outgoing material* (at the moment of sale/export/move, incl. components moving from the DMF to the CRTC for reuse and vice versa) and introduce *monthly stock taking* of all work in progress material (material to be processed and semi-finished goods)
It is important to note that accurate and consistent registration of material flows is needed in order to be able to prevent or detect irregularities such as theft or fraud of material. Given the high value of some fractions, this is a non-negligible risk that should be managed appropriately. The everyday practice at waste collection and treatment facilities worldwide confirms the relevance of this concern.

- **Perform material balances**

Observation: Due to the absence of consistent weight-based registration, no effective control can be performed to follow up on material flow integrity (i.e. detecting theft or loss of material) or to follow up on the quality and value of incoming material.

Recommendation: Introduce consistent weight registration and make a material balance every 3 months, i.e.

Weight (incoming material)
= Weight (material in stock/stored+ work in progress material + materials going out/sold)

2. Design a plant lay-out for the new workshop

At the moment of the field visit, construction works for the new e-waste workshop were nearly completed. A plant lay-out was designed for the new workshop, taking into account the dimensions of the facility.

The main characteristics of the new plant lay-out are:

- Estimated facility capacity of 50 tonnes/month, i.e. 600 tonnes per year

- Use of shared incoming department for CRTC and DMF
- A clear allocation of available space to functional departments defined in the updated process flow
- Plant lay-out designed for easy, quick and safe flow of materials throughout the process
- Up to 8 manual dismantling workstations possible with the new workshop dimensions
  Up to 4 mechanical workstations possible based on the new workshop dimensions

Efficient use of available space by use of pallet racks for incoming and outgoing material. Calculations on required space were based on current and estimated throughput at the demanufacturing facility and were cross-checked with the UNIDO-KERP business planning tool.

The insertion of recycling equipment on the floor plan was based on typical dimensions of machines following a brief market study.

For the plant lay-out, please refer to the following annexes:

- "Annex 4a - Plant lay-out presentation"

- "Annex 4b - Plant lay-out technical drawings"

Please refer to "Annex 6b – Production capacity assumptions" for estimated production capacity.

3. Recommended equipment to upgrade the DMF

Based on a needs assessment and a benchmarking with similar facilities, a list of recommended equipment was drafted to upgrade the DMF in terms of processing capabilities and efficiency of treatment. Please find below an overview of the recommended equipment.

#	Description	Purpose description	Prior	Remark
	Machines - recycling operations			
1	Combined metal press / vertical baler	Reduce volume of plastic, metal, etc.	1	
1	Allround shredder	Reduce volume of plastic, metal, etc. and destroy data carriers: hard drives, tapes, etc.	2	Can be replaced by vertical baler (reduce volume) and manual destruction (data wiping)
1	Cable shredder - 0,5-5 mm cable	Separate metal / plastics for small cables	2	
1	Cable stripper - +5mm cable	Separate metal / plastics for large cables	1	
1	CRT cutter	Process CRT monitors	1	
1	Portable HD degaussing machine	Data wipe at client premises	2	Data carriers can destroyed manually (e.g. drill a hole in HDD)
	Transport - storage - security			
1	Collection truck	Dedicated DMF vehicle for e-waste collection	2	A shared CRTC-DMF vehicle is already available
1	Platform scale + ramp	Weigh incoming, weigh outgoing material, stock taking	1	
2	Pallet jacks	Move around input & output material on ground floor	1	
1	Fork lift	Store output fractions in pallet racks	2	A fork lift is already available
1	Safe	Store valuable items & cash supply	1	
1	GPS tracking system	Track movement of collection vehicles to prevent theft or loss	1	
1	CCTV camera system	Track incoming & outgoing movements to prevent theft	1	
1	Fire fighting system	Fire fighting	1	
	Dismantling equipment & PPE			
5	Mechanic's tool sets	Manual dismantling	1	
5	Electric screw driver tools	Semi-automatic for improved efficiency	1	
	High end dust protection masks	Workers' protection	1	
	High end earmuffs			
	Cut proof gloves + arm protectors			
	Gravity feed eye wash station			
	Overcoats			
	Goggles		1	
	Safety shoes			
	Storage equipment for fraction sorting & export			
50	Pallet boxes		1	
500	Big bags		1	
40	Gaylord boxes		1	
25	Box on wheels		1	
20	Big drums		1	
40	Medium drums		1	
30	Small drums		1	
	Pallet racks		1	
	Roller conveyors		1	

The equipment marked priority 1 starts from the premise that the DMF should be sufficiently equipped in order to start up operations of collecting, dismantling and pre-processing the vast majority of electronic waste in a comfortable way.

Equipment marked priority 2 is machinery that will further increase the efficiency or effectiveness of the treatment process but isn't considered vital, given the existing resources and equipment already present.

Please also note that, under the Best-of-2-worlds approach, manual dismantling is recommended over automatic processing given the relatively low cost of labor and the fact that the quality of manually dismantled fractions is higher, resulting in higher revenues.

Please find below a short justification for the recommended equipment:

- **All-round shredder or vertical baler**

  An all-round shredder reduces the volumes of fractions taking up a lot of space when stored unprocessed such as (plastic) CRT or (metal) computer casings. An all-round shredder can occasionally be used as for shredding CPU casings or hard disk drives to ensure data erasure of data carriers by means of physical destruction.

  Like a shredder, a vertical baler also reduces the volume of fractions taking up a lot space when stored unprocessed such as plastic or metal casings thus can be used instead of a shredder. A vertical baler crushes and compresses the material instead of shredding it. The process does not ensure any data destruction. In this case, data carriers should be destroyed in another way (e.g. drilling a hole in a HDD or using a degaussing machine).

  In principle, these fractions can also be shredded or crushed manually however this is very time consuming, hence the classification priority 1.

- **Degausser**

  Degaussing is the process of decreasing or eliminating a remnant magnetic field. Data is usually stored in the magnetic media, such as hard drives, floppy disks, and magnetic tape, by making magnetic domains change their magnetic alignment to be in the direction of an applied magnetic field. Degaussing, commonly called erasure, leaves the domains in random patterns with no preference to orientation, thereby rendering previous data unrecoverable. Proper degaussing of data carriers will ensure there is insufficient magnetic remanence to reconstruct the data.

  As such, as degausser can be used to erase all information on magnetic data carriers. Since a degausser is a very portable device, it has the added advantage that data erasure can be done on the client's premises while he is present.

  However, data erasure can also be ensured by physically damaging the data carrier beyond repair (e.g. drilling a hole in a HDD). Hence, the classification priority 2.

- **Cable shredder and/or stripper**

  Cable shredders and strippers separates the metal core from the plastics – mostly PVC - insulating body of the cable. Depending on the specifications, a cable shredder may not be able to process large and solid core cables (+5 mm diameter). A cable stripper is a cheap alternative to process larger these cables.

  Shredding and stripping cables adds value by enabling local processing of this material with an approximate value of 1.000 EUR/ton at the time of writing, thus avoiding the need to export these fractions.

Although we feel a cable shredder is a very useful device to have, it is not strictly necessary. Hence the classification priority 2 for the shredder, and priority 1 for the stripper given the low cost of purchase.

- **CRT cutter**

A CRT cutter allows the separation of CRT funnel and panel glass, as well as the removal of fluorescents from the inside of the panel. Its main purpose is to separate the different hazardous fractions and to reduce volume during transport.

A rough calculation learns that approximately 600 CRT tubes can fit into a 40' sea container when shrink-wrapped on a pallet or stacked into a big bag (6 tubes x 5 layers on 1 pallet x 20 pallets). With an average weight of 8 kg per tube, the total load weighs 4.8 tonnes, which is relatively low, the reason being that the volume determines the maximum capacity of the container, not the weight. Assuming a total transport cost from Ethiopia to Europe of 3,000 EUR per container, the transport cost per tonne is 625 EUR.

When the tube is cut with the CRT cutter and the processed CRT glass is transported in UN certified big bags or Gaylord boxes, up to 25 tonnes of CRT glass will fit into a container. Now it is the weight (payload) that determines the maximum capacity of the container, not the volume. Assuming the same costs of transport for a container (3,000 EUR), the transport cost is now reduced to 120 EUR/tonne.

Therefore, a CRT cutter does not necessarily add value but reduces international transport costs for fractions that cannot be recycled locally (today). Both manual and automatic CRT cutters are available on the market, manual cutters being the most economic choice in a best-of-both worlds approach.

- **Transport, storage and security equipment**

Given the large investment amount of buying a truck, a collection truck is considered very useful but not vital to start up operations. Alternatively, a collection vehicle could be shared with CRTC, a dedicated vehicle could be leased or a second hand vehicle could be purchased, depending on budget limitations. Hence the classification of priority 2.

Pallet jacks are minimal required equipment to be able to move around pallets from one department to another. Another platform scale and ramp is considered necessary to ensure a proper weight-based registration throughout the process. Hence, these items have received priority 1.

A forklift is a very useful tool to move materials around and store them on different levels using pallet racks. However, a forklift is currently already available at CRTC. It could be shared with the DMF and should offer sufficient transport capacity for a shared use, including estimated increases in dismantling throughput. Hence, we gave this item priority classification 2.

To ensure a comfortable level of security, a safe to store valuable items, GPS tracking devices to monitor movements of collection vehicles and CCTV cameras and to track incoming and outgoing movements. These three measures are aimed at preventing loss or theft of material, which is considered a significant weakness in the current process organization. A firefighting kit is needed to be able to take action in case of fire. All four measures are related to safety & security providing a high degree of insurance at a very reasonable cost, hence their classification under priority category 1.

- **Dismantling equipment, PPE and storage equipment**

  Last but not least, the budget includes dismantling toolkits, a starting quantity of PPE and several containers, boxes and bags to store materials in. These are considered minimum equipment to be able to work in a safe and efficient way, hence their classification under priority 1.

The estimated amount of the minimally required equipment (priority 1) is 100.000 USD, with another 120.000 USD of equipment considered optional (priority 2).

Please note that the list of proposed equipment is a proposal for a minimally equipped dismantling center based on the budget communicated to us, estimated prices and equipment levels of other facilities in the region, still leaving some room for choices made by the DMF.

For the list of proposed equipment, please refer to the following annex: "Annex 5 - Proposed list of equipment"

4. Design an updated process flow

Based on the observations made during our process walkthrough, interviews conducted with management of the DMF and benchmarking with similar facilities, an updated process flow was designed.

The process flow has been designed for use in the new workshop ("to be" situation). Thus it is based on the updated plant lay-out (cfr. section F.2.) and the proposed list of equipment (cfr. section F.3.).

The key characteristics of the updated process flow are:

- Clear allocation of available space to functional departments, i.e.
  - Incoming department (shared between CRTC and DMF)
  - Refurbishment department
  - Incoming storage area
  - Dismantling workstations
  - Semi-automatic workstations
  - Workshop intermediate storage area
  - Outgoing department
- Clear allocation of responsibilities (executive and supervisory) at the different steps of the process
- Consistent weight registration at the different steps of the process
- Consistent use of templates[4] for data registration

Please refer to "Annex 6a - Updated process flow" for a presentation of the updated process flow.

[4] Such templates will be developed or tine-tuned with the DMF during the planned training in Q2 2015.

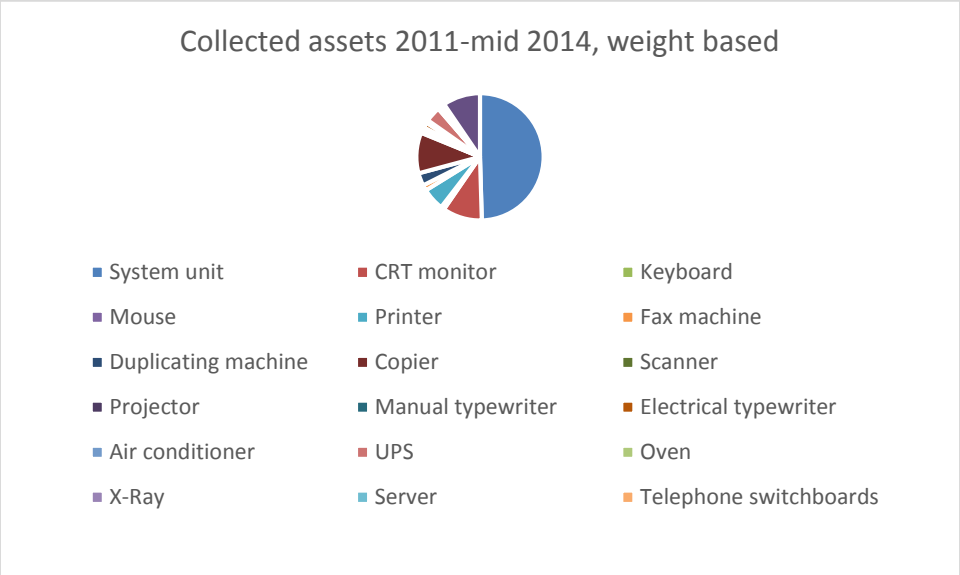
5. Valorization & treatment of output fractions

Inventory of collected assets

As part of our objective to provide a way forward for the valorization of output fractions, we first tried to obtain a correct and up-to-date inventory of collected assets based on the DMF management's periodically compiled reports.

The conclusion of this exercise is that the DMF has collected around 9,500 assets from the start of the project in 2011 until July 2014. The total weight of the volume collected is estimated at 55 tonnes (cfr. Annex 7a).

Of all collected material, the majority consists of PC system units, i.e. the PC tower (50% of total est. weight), CRT monitors (10% of total est. weight), copy machines (10% of total est. weight) and printers (6% of total est. weight).



There is a slight discrepancy of around 8 % between the inventory of collected assets and the inventory of output fractions in favor of the output inventory. It can most likely be explained by the assumptions made with regard to the average composition of assets or lack of registration of the initial assets collected.

Moving forward, it is highly recommended to introduce consistent weight based registration (as opposed to number of assets) for incoming material to be able to ensure tracking of material flows throughout the process.

For the inventory of collected assets, please refer to the following annex:

- "Annex 7a – Inventory of collected assets 2011-2014"

As a side note, the volume collected over the three year period is low compared to similar facilities in the region. For more information on the break even calculations for the DMF, we refer to the "EWaMP business plan" document (under development at the time of writing).

Inventory of output fractions

We also performed a stock taking of all available output fractions. Since not all fractions were accessible to weigh (cfr. current process recommendations), the inventory of output fractions remains a rough estimation. Based on this exercise, the total weight of output fractions is estimated to be 51.5 tonnes with an estimated value of around 35,000 EUR, based on current local and international prices (August 2014).

For the inventory and estimated value of output fractions, please refer to the following annex:

- "Annex 7b – Inventory of output fractions 2011-2014"

Applicable legislation

With regard to the export of the components for sale on the international market, it is important to look at the applicable legislation both at the export and import side, both on the national and international level.

The Basel Convention is the most applicable legislation in most cases. However, it is important to note that countries can have their own definitions of hazardous waste (art. 3) and may also conclude bilateral, multilateral or regional agreements (art. 11). The leading principle is that the most stringent legislation applies.

The most common codes for ICT material are:

A 1180:

- *Waste electrical and electronic assemblies or scrap containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitor, or contaminated with Annex I constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (not the related entry on list B B1110)*

In practice, this code typically includes

- complete electrical or electronic appliances;
- old, industrial or military IT appliances;
- batteries containing equipment or components;
- equipment or components possibly containing hazardous material;
- printed wiring boards (mostly low grade) that haven't undergone any depollution process;
- printer cartridges with hazardous materials inside (e.g. cadmium sulphide, selenium-arsenic), etc.[5]

A 2010:

- *"Glass waste from cathode ray tubes and other activated glasses"*

This code typically includes CRT tubes and CRT glass.

B 1110: Electrical and electronic assemblies:

- *"Electronic assemblies consisting only of metals or alloys*
- *Waste electrical and electronic assemblies or scrap (including printed circuit boards)* ***NOT*** *containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with Annex 1*

[5] For further guidance on waste classification, please refer to IMPEL, 2010. "Waste(s) watch"

constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) or from which these have been removed, to an extent that they do not possess any of the characteristics contained in Annex III.

- *Electrical and electronic assemblies (including printed circuit boards, electronic components and wires) destined for direct reuse and not for recycling or final disposal."*

In practice, this code typically includes EEE fitted for reuse, electrical or electronic equipment and components not containing hazardous material, depolluted printed circuit boards[6], printer cartridges without any hazardous materials, etc.

Please note that, in order for any material to be classified under waste code B 1110, all hazardous components have to be removed (referred to as "depollution") such as batteries, accumulators, condensers, capacitors, etc.

For import into Europe, it is important to note that OECD guidelines and the EU waste shipment regulation (1013/2006/EU) are applicable and replace parts of the Basel Convention, although these regulations are based on the Basel Convention.

In the EU waste shipment regulation, a distinction is made between waste classified as "green listed waste", following the general information requirements (Annex VII) procedure, and "amber listed waste" following the notification procedure of the EU waste shipment regulation. Specifically for electronics components, the code B 1110 of the Basel convention is replaced by the following 2 "green listed waste" codes:

- GC010 Electrical assemblies consisting only of metals or alloys
- GC020 Electronic scrap (e.g. printed circuit boards, electronic components, wire, etc.) and reclaimed electronic components suitable for base and precious metal recovery

As Ethiopia is signatory of the Basel Convention, imports to the EU of GC020 waste for recovery purposes is allowed under the conditions of Article 18 of EU Regulation 1013/2006 (the green list procedure).

Article 18 Waste to be accompanied by certain information

1. Waste as referred to in Article 3(2) and (4) that is intended to be shipped shall be subject to the following procedural requirements:
(a) In order to assist the tracking of shipments of such waste, the person under the jurisdiction of the country of dispatch who arranges the shipment shall ensure that the waste is accompanied by the document contained in Annex VII.
(b) The document contained in Annex VII shall be signed by the person who arranges the shipment before the shipment takes place and shall be signed by the recovery facility or the laboratory and the consignee when the waste in question is received.

2. The contract referred to in Annex VII between the person who arranges the shipment and the consignee for recovery of the waste shall be effective when the shipment starts and shall include an obligation, where the shipment of waste or its recovery cannot be completed as intended or where it has been effected as an illegal shipment, on the person who arranges the shipment or, where that person is not in a position to complete the shipment of waste or its recovery (for example, is insolvent), on the consignee, to:
(a) take the waste back or ensure its recovery in an alternative way; and
(b) provide, if necessary, for its storage in the meantime.

[6] Please note that the interpretation of the Basel convention of PWB classification is stricter than the OECD guidelines and EU regulations (adoptions of the Basel convention in the OECD/EU countries) on this matter. As a result, the applicable legislation will depend on the country of export (are there any specific national guidelines?) and import (OECD/EU or other country?).

The person who arranges the shipment or the consignee shall provide a copy of the contract upon request by the competent authority concerned.

3. For inspection, enforcement, planning and statistical purposes, Member States may in accordance with national legislation require information as referred to in paragraph 1 on shipments covered by this Article.

4. The information referred to in paragraph 1 shall be treated as confidential where this is required by Community and national legislation.

This interpretation has been confirmed by the Belgian and the Dutch environmental protection agencies.

However, specific requirements may still exist in the country of export that require to follow the notification anyway. In case of disagreement, it is the most stringent legislation that will be applied. The EU waste shipment regulation is only applicable when importing to the EU. The interpretation and application of this legislation can differ slightly in the different EU member states.

Therefore, it is crucial to double check the applicable export and import regulations before initiating any shipment.

Next steps for international shipment

Based on the inventory of output fractions, a draft proposal for the valorization of the current stock of output materials on the international market was made.

For the sake of simplicity we have assumed that the materials would be exported from Ethiopia into the Netherlands. We have assumed that Ethiopia follows the interpretation of the Basel convention into the EU waste shipment regulations (green listed/amber listed waste). This needs to be confirmed at the time of shipment. We have chosen the Netherlands as an example because they have opted for a very clear and pragmatic interpretation of green listed waste based on the type of material (component/entire appliance) and in the intended recovery process (base and precious metal recovery).

"Code GC020 constitutes electronic scrap (e.g. printed circuit boards, electronic components, wire, etc.) and reclaimed electronic components suitable for base and precious metal recovery. It is only applicable to electronic elements of dismantled electronic appliances. Not to electronic appliances as a whole. Non-electronic elements have to be excluded, so it is suitable for base and precious metal recovery."[7]

For the proposed composition of a first international shipment, please refer to the following annex:

- "Annex 7c – Proposed composition first international shipment"

Moving forward, we recommend DMF to initiate the procedure with regard to the sale of these fractions (requesting quotes, choice of supplier) and then validate the procedure to be followed (green list or amber list) for the export of the materials.

Before shipment, it is highly recommended to obtain a formal opinion from the relevant competent authorities as to the waste classification and the applicable legislation in the country of export and import for the first shipments.

Internally within the DMF, we recommend to develop internal procedures for organizing these shipments given the complexity of these processes.

[7] Source: E-mail from Rijkswaterstaat (Dutch Ministry of Infrastructure and environment)

ANNEXES

ANNEX 1: Sorting of printed circuit boards

ANNEX 2: Recommended storage and packing

ANNEX 3: Updated input and output categories

ANNEX 4a: Plant lay-out presentation

ANNEX 4b: Plant lay-out technical drawings

ANNEX 5: Proposed list of equipment

ANNEX 6a: Updated process flow

ANNEX 6b: Production capacity calculation

ANNEX 7a: Inventory of collected assets 2011-2014

ANNEX 7b: Inventory of output fractions 2011-2014

ANNEX 7c: Proposed composition first international shipment