TOWARDS ENVIRONMENTALLY AND SOCIALLY SOUND E-WASTE MANAGEMENT IN W-AFRICA – RESULTS FROM A SURVEY IN GHANA AND EUROPE

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Abstract: In 2009, the VROM-Inspectorate and NVMP assigned a study on socio-economic impacts of informal WEEE-management and improvement potentials in Ghana.
The project aims at creating favorable social and economic conditions in the e-waste recycling sector and to elaborate on the feasibility of international recycling co-operations, also for the purpose of enhancing resource efficiency and closing material cycles. To achieve these goals, the e-waste recycling system in Ghana was studied and compared to the end-of-life management in Europe. This was performed to analyze the applicability of alternative recycling technologies in Ghana on the basis of specific environmental, social and economic benefits. Drawing from this research, possible business models were sketched that could help to tap improvement potentials. Special emphasis was on strategies to incorporate the existing informal sector. This contribution presents key findings from this research. The study was carried out by the Öko-Institut e.V. (Germany) and Green Advocacy (Ghana).

1. INTRODUCTION

As currently documented by Prakash et al. [2], the informal e-waste recycling system has severe environmental and health impacts in Ghana. These impacts do not only affect the people engaged in the collection and recycling of e-waste, but also the communities living in the surroundings of the Agbogbloshie Metal Scrap Yard and other comparable recycling clusters. Environmental key concerns are the open incineration of cables to recover copper, the release of CFCs during the recycling of fridges and freezers, the open incineration of plastics and the uncontrolled disposal of hazardous material like capacitors, low- and medium-grade printed wiring boards and CRT-glass. Social key concerns are low revenues, excessive working hours, severe health and safety risks, child labor and the absence of any kind of social security system.

On the other side, the currently practiced WEEE-collection and recycling in Ghana also has some distinct socio-economic benefits, which can be seen as the key reasons for people's engagement in this business: First of all, it enables some form of reliable income for 6,300 to 9,600 people currently engaged in collection and recycling. Taking into account the chronic un- and underemployment amongst urban poor in Ghana, this aspect is of crucial importance. Additionally, Prakash et al. [2] revealed that the majority of people engaged in WEEE-collection and recycling originated from the poor northern parts of Ghana, which suffers chronic food-insecurity. The WEEE- and scrap metal business is one of the few sectors open to migrants from the north. Here, another important factor comes in: While many other economic activities require initial investments in terms of money or working-time, the WEEE and scrap metal business can be taken up with almost no training and investment costs. In contrast, e-waste and scrap metal collection and recycling enables a rapid cash-flow, so that workers already receive money after their first working day.

Taking into account the environmental and socio-economic impacts, it must be concluded that the currently practiced e-waste collection and recycling in Ghana needs to be transformed into a more sustainable system. Nevertheless, such transformation also needs to take into account the socio-economic demands of urban poor and migrants from northern Ghana. Therefore, future e-waste collection and recycling systems need to comply with the following principles:

- significantly reduce environmental impacts,
- significantly reduce health risks for workers and neighboring communities,
- preserve the jobs of collectors and recyclers already engaged in this sector,

- enable the implementation of social and environmental standards.

The project seeks to identify pathways to improve e-waste recycling in Ghana in this manner by proposing technologies1[1] enabling all, environmental, social and economic improvement potentials. In particular, such multiple gains can be realized by technologies enabling improved resource recovery rates, thus potentially higher revenues for recyclers. Thereby, solutions are not only sought locally, but also in co-operations with international recycling networks and markets. As a side-effect, such solutions will also enhance resource efficiency and achieve closed material cycles. With regard to the currently existing collection and recycling system, one key aspect is the applicability within or close to the current small businesses structure in Ghana.

The research was carried out within project "Socio-economic assessment and feasibility study on sustainable e-waste management in Ghana", assigned by the Inspectorate of the Ministry of Housing, Spatial Planning and the Environment of the Netherlands (VROM-Inspectorate) together with the Dutch Association for the Disposal of Metal and Electrical Products (NVMP) in 2009.

The project is closely related to the E-waste Africa Project, implemented within the framework of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which was launched in five West-African countries, namely Nigeria, Benin, Ghana, Côte d'Ivoire and Liberia.

The study was carried out by Öko-Institut e.V. (Germany) and Green Advocacy (Ghana).

2. METHODOLOGY AND SCOPE

In order to identify pathways for improved e-waste recycling in Ghana, the project carefully analyzed and compared the currently practiced recycling technologies in Ghana as well as best available recycling technologies applied in Europe. This is performed with a view to analyze the applicability of these recycling technologies in the Ghanaian context on the basis of their specific environmental benefits as well as practical considerations. Furthermore, it was analyzed, which recycling steps can be carried out locally within Ghana and which steps have to make use of an international division of labor, namely the export of certain fractions or substances to up-to-date treatment facilities. This kind of exports are only considered if no other suitable local processing seems possible or would require investments and treatment volumes that would be clearly oversized for the current waste management structure and volumes.

On the basis of the best applicable recycling technologies, the economic, environmental and social improvement potentials are analyzed and quantified as far as possible. With regards to social improvement potential, special emphasis is on health and safety issues related to the best applicable technologies, as well as its estimated labor intensities.

Drawing from this analysis, possible business models are sketched that could help to tap the described improvement potentials. Thereby, special emphasis is on the possible roles of the informal sector and structures to rather include these informal players instead of creating competition between a formalized and non-formalized recycling industry.

The analysis is conducted for three key product groups, namely desktop computers, CRT-devices and fridges and freezers. The selection of product groups is based the following criteria:

- The product group constitutes an important share of the total e-waste volumes in Ghana;
- The end-of-life phase is of particular environmental concern;
- Improved end-of-life management can serve as model for the management of other product groups with similar characteristics.

From a value chain perspective, the scope encompasses collection and pre-processing of e-waste. End-processing is included insofar as for each output fraction from pre-processing, final treatment options are proposed. Nevertheless, the currently applied end-processing options where not analyzed on a facility or location level. Additionally, businesses and approaches to repair and refurbish old and obsolete e-products are excluded from this analysis.

3. RESULTS

3.1. Desktop PCs

In case of desktop PCs, the comparison of the presently applied recycling technologies and the best applicable technologies reveals that there are significant untapped economic, environmental and social improvement potentials. These potentials can be realized by manual pre-treatment in Ghana and exporting of the precious metals bearing fractions to one of the few pyrometallurgical refineries in Europe, Canada or Japan. In the Ghanaian context, the best applicable recycling technologies for desktop PCs can be sketched as follows:

- House-to-house collection of e-waste;
- Manual pre-treatment, including deep dismantling until the level of parts of sub-components;
- Mechanical shredding or granulation of cables;

[1] In line with the analysis performed in Schluep et al. [4], the term „technology" in this report refers not only to „technical installations, but also to skills, processes and combinations thereof. In this respect, a systematic manual dismantling of an electronic device or a well elaborated chain of different processes is regarded as technology" [4].

- Further manual pre-treatment of low grade copper fraction to reduce plastic content;
- Refinery of steel- and aluminium-fraction in domestic plants;
- Refinery of high grade precious metals fraction in pyrometallurgical refineries overseas;
- Refinery of copper and low-grade copper fraction in copper- or steel-copper refineries abroad;
- Controlled incineration / energy recovery or land filling of remaining plastic fraction.

From environment's point of view, the above mentioned e-waste management system would not only lead to export flow of high concentrations of heavy metals and organic pollutants from Ghana to state-of-art facilities, but at the same time, it will lead to higher recovery rates – 87% above – for precious metals, such as gold, silver and palladium. Consequently, with these optimized recovery rates of silver, gold and palladium, a total of 5.23 kg CO_{2eq} could be saved per desktop PC if compared to primary mining of the same amount of metals.

In economic terms, higher recovery rates of precious metals, as achieved in the proposed state-of-art technologies, would lead to in an increase in the revenue from the recycling of one desktop PC from US$ 7.21 to 13.19. Under usual conditions these values can compensate the costs for manual pre-treatment, logistics, transport and refinery. From the type of operations needed in Ghana, it is obvious that this business is largely independent from investments into machinery parks or infrastructure, and that manual pre-processing operations can be run by medium and low skilled workers. Therefore, the business is suitable to be implemented within or attached to the current informal sector recycling in Ghana.

3.2. CRT-devices

In case of CRT-devices, the comparison of the presently applied recycling technologies with the best applicable technologies reveals that there are considerable environmental improvement potentials, especially in terms of managing the hazardous fractions like CRT-glass, the internal phosphorous coating and plastics. However, the environmentally sound management of these fractions is costly and would yield clearly less revenues than under presently applied recycling technologies. In the Ghanaian context, the best applicable recycling technologies for CRTs can be sketched as follows:

- House-to-house collection of CRTs and careful handling in order not to damage the tubes;
- Manual dismantling into main fractions;
- Manual upgrading of printed circuit boards;
- Compaction of tubes under a fume hood with attached filter system;
- Refinery of steel- and aluminium-fraction in domestic plants;
- Refinery of precious metals fraction in pyrometallurgical refineries overseas;
- Refinery of copper fraction in copper-refineries abroad;
- Controlled incineration / energy recovery or controlled disposal of remaining plastic fraction
- Careful use of glass culets in construction sector or disposal as hazardous waste;
- Disposal of phosphorous dust as hazardous waste.

The comparison between the net material values of the presently applied recycling technologies and the best applicable recycling technologies shows, that revenue from recycling of one CRT-TV could be increased from US$ 7.67 to 9.84. However, this calculation does not include the costs for environmentally sound management of the CRT-glass and the disposal of the internal phosphorous coating. Considering the current oversupply of CRT-glass, leading to a situation where providers of the glass have to bear costs of about US$ 160 per metric ton for its environmentally sound end-processing in copper smelters, the revenues from environmentally sound recycling of CRTs are lower than the revenues from the currently practiced recycling (declining from US$ 7.67 to 7.11) – not even taking into account the costs for sound disposal of the phosphorous dust and possible charges for transport and the controlled incineration of plastics. Therefore, it is expected that profit orientated enterprises will not engage in environmentally sound CRT-recycling without additional financing systems or other safeguard mechanisms that insure a proper handling of all fractions of CRT-products. Thus, any business models to implement environmentally sound CRT-recycling can only be successful, if laws and regulations clearly outline the recyclers' responsibility for all waste fractions. Additionally, sound CRT-recycling could be supported by identifying suitable management options for critical fractions. This could include:

- the identification and development of disposal sites for hazardous wastes;
- further exploring the feasibility of using CRT-glass in the construction sector.

3.3. Fridges and freezers

In case of refrigerators, the comparison of the presently applied recycling technologies and the best applicable technologies revealed that there are significant untapped environmental and possibly economic improvement potentials. These potentials can be realized by the recovery of CFCs and HFCs from cooling circuits and foams and subsequent destruction of these Ozone Depleting Substances in dedicated facilities. Additionally, the sound management of hazardous components and a better utilization of the plastic fraction add to the benefits of sound fridge recycling. Economic benefits can be tapped, if the CFC and HFC-recovery and destruction are marketed using one of the existing emission reduction certification schemes, such as the Carbon Action Reserve (CAR) and the Voluntary Carbon Standard (VCS) [1], [6]. In the Ghanaian context, the best applicable recycling technologies for fridges and freezers can be sketched as follows:

- House-to-house collection of fridges and freezers and careful transport to prevent leakages of the cooling circuit;
- Semi-automated extraction of CFCs from cooling circuits;
- Automated recovery of CFCs from foams;
- Refinery of steel- and aluminium fractions in domestic plants;
- Export of copper fraction;
- Local recycling of polystyrene;
- Marketing of PUR-powder as oil binding agent;
- Export and destruction of CFCs in certified facilities;
- Controlled incineration / energy recovery of oil and remaining plastic fraction;
- Controlled management of hazardous fraction.

From an environmental perspective, the best applicable technologies, which would recover a minimum of 90% of total CFCs contained in cooling circuit as well as foams, would lead to a proper management of up to 2–7 t CO_{2eq} per device [3]. Together with better utilization of plastics, mainly polystyrene – a potential which is neglected in presently applied recycling technologies –, revenues from CO_2 emission trading would yield much higher economic benefits. However, investment costs for setting up such facilities would range from US$ 280,000 for basic machinery to recover CFCs from cooling circuits to US$ 6.3 million for comprehensive recovery facilities. On the other hand, management aspects related to export of CFCs, certification and compliance within the framework of emission trading schemes, would be quite complex. Thus, informal e-waste sector might not be in the position to manage such a recycling system on its own. However, the informal e-waste sector should still be engaged in collection of obsolete fridges, transport to the recycling facility and the manual recycling steps. In this way, businesses would closely interlink with the current e-waste recycling structures and avoid competition in acquiring obsolete fridges.

4. CONCLUSION AND OUTLOOK

There are currently various untapped improvement potentials for e-waste recycling in Ghana. Nevertheless, many of these potentials can only be realized if a sound regulative framework – including definition of responsibilities for hazardous fractions, financing mechanisms and enforcement strategies – is installed. This is of particular importance, as many hazardous output fractions from e-waste recycling do result into net costs if managed appropriately. Therefore, recyclers operating under free market conditions in a non-regulated environment will very likely choose the cheapest possible management option, which is mostly uncontrolled dumping and burning.

Nevertheless, there are some niche markets, which could allow all, environmental, economic and social improvements at the same time – even in the absence of a full functioning regulative framework. These potentials can mainly be found in the management of precious metals bearing fraction (printed wiring boards and IC-contacts) and the sound recovery and destruction of CFCs from fridges, freezers and air-conditioners.

As the potential related to the precious metals content of electronics does not require significant investments into machinery, but is in turn quite labor intensive, it can well be managed by the current recycling structures in Ghana. Nevertheless, these structures would need to fulfill certain preconditions before engaging in this market. Most importantly, the informal sector would need to formalize in order to be able to sign contracts with internationally operating companies and to apply for export licenses. Alternatively, also intermediaries (traders) could establish the link between informal sector and refineries. Thereby they would act as formal joint between the widely informal e-waste sector in Ghana and the refining companies. Nevertheless, such a business model might be critical in situations where intermediaries have a monopoly position and can control the local prices for pre-processed e-waste. From other resource markets, it is known that many intermediaries that deal with informal sector activities use such monopoly positions to bring down prices and to maximize their own profit margins [5].

To realize the potentials related to CFC recovery and destruction require significant investments into machinery and also have to be tied up to international certification and emission reduction markets. Therefore, it is questionable whether the informal e-waste recycling sector in Ghana is capable of realizing this market niche alone. Nevertheless, CFC-recovery projects could still be embedded into the current recycling structures, as collection and metal pre-processing (after CFC-recovery) could be carried out by the existing recycling structures. This step would also prevent the loss of jobs caused by mechanized recycling and might help to create a nucleus for an improved e-waste recycling industry in Ghana.

With regard to an effective and timely implementation of the described business potentials, it is recommended to set up a pilot implementation and demonstration project that facilitates the environmentally sound recycling of e-waste. Such a project should not only tap the potentials described above, but also set the course for an implementation that insures social gains for the informal e-waste recyclers in Ghana. Additionally, efforts should be made to identify feasible and cost-efficient end-of-life management options for hazardous fractions.

5. LITERATURE

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