

Evaluation of Flow of Waste Electrical and Electronic Equipment in Benin

^{1,2}Martin Pépin AINA, ²Julien ADOUNKPE, ³Daouda MAMA, ³Waris CHOUDI, ⁴Mansourou MOUDACHIROU, ⁵Guy MATEJKA

¹Laboratoire des Sciences et Techniques de l'Eau de l'Ecole Polytechnique d'Abomey – Calavi 01 BP 2009 Cotonou, Bénin E-mail: marnickson@yahoo.fr, Tél 00229 96 613936

²Laboratoire d'Ecologie Appliquée Faculté des Sciences Agronomiques de l'Université d'Abomey Calavi 01 BP 528 Cotonou, Bénin

³Laboratoire d'Hydrologie Appliquée Faculté des Sciences et Techniques de l'Université d'Abomey Calavi

⁴Laboratoire de Pharmacognosie et des Huiles essentielles de l'Université d'Abomey – Calavi

⁵Groupe de Recherche Eau Sol Environnement Ecole Nationale Supérieure d'ingénieur de limoges, Ester technopole 87068 Limoges cédex

Abstract

The present study focused on the flows of Waste Electrical and Electronic Equipment (WEEE) entering and circulating in Benin, the actors of the chain and the analysis of the current situation for the implementation of a strategy to strengthen local capacity to meet the requirement of the flow of Electrical and Electronic Equipment (EEE) for reuse in some African countries and to increase the sustainable management of resources by the recovery of materials in e-waste. The results of various surveys show that tons of electrical and electronic equipments out of service reach the Benin territory in a range of from 6781 tons in 2004 to 8560 tons in 2007 with a high rate of household penetration. These new or used equipments are managed by different groups of people that are consumers (large and small), repairers, collectors and recyclers. Note that, recycling is highly developed in the informal sector and mostly deals with the recovery and the recycling of electronic circuits (diodes, transistors, speaker, strength, magnet, etc.) and other parts such as aluminum, plastic, copper, etc.. The results obtained allowed to identify the market share of different producers, to evaluate the flow of new and used equipments, to establish the chain of actors and traceability of equipment. Also the socio - economic impacts and the environmental health issues were evaluated.

Keywords: Waste, Equipment, Electrical, Electronics, Environment.

INTRODUCTION

Waste management in the world and particularly in Benin is facing many difficulties, both in terms of technical, economic and organizational and methodological. The need for waste management is dictated by the health and environmental imperatives. Health and environmental issues are so crucial that generate waste is increasing in quantity and is diversified. Waste Electric and electronic equipment (WEEE) is of a particular challenge. The technical progress observed in the recent years for the manufacture of electrical and electronic equipment with multiple features and new models has prompted consumers to want high quality devices and has exponentially increased the sale of those devices (LaCoursiere, 2005). Nowadays, problems arising from WEEE are due not only to their very strong growth but also to their content ((Brodersen et al., 1992, Lee, 2005).

For example, several million tons of WEEE were generated in the U.S., Europe and Japan (Kang and (Kang H-Y and Schoenung JM, 2005; Beck, 2004; Clean Japan Center, 2002). In 2001, the amount of electronic waste produced in the United States was estimated to 2.26 million tons. In 2004, in Europe, the electronic waste quantity was 14 kg per person (Beck, 2004). The UN says the world produces 20 million to 50 million tons of WEEE each year (Schwarzer et al., 2005).

Several studies have shown contamination of WEEE recycling facilities surrounding environment by Polybrominated Diphenyl Ethers (PBDEs) (Wang et al., 2005); by carcinogenic and bioaccumulations and polycyclic aromatic hydrocarbons (PAHs) (Yu et al., 2006); with heavy metals such as copper, lead, zinc and cadmium (Wong et al., 2007), and similarly with heavy metals associated with fine particles (Deng et al., 2006). Without proper treatment of hazardous substances contained in these wastes, they can be found in the environment and possibly in humans. This is why several countries have banned the incineration and landfilling of WEEE (Panate, 2009). This research aims to improve the level of information available on the Electric and Electronic Equipment (EEE) and WEEE, in order to assist exporting and importing countries in decision making and enhance the communication among them.

1 Method

The statistics data collected are based on the latest population census of Benin to assess the quantities of electrical and electronic equipment in households. Field surveys, polls, the assessment based on the relative size of the companies contacted were used to determine the flow of electric and electronic waste (EEW).

- Analysis of material flows

The collected data allow the usage of the «consumption and utilisation method." The method assumes that a basket of electric and electronic equipments (EEE) is available per household. For each electric or electronic device, a supposed weight (Huisman Magalini et al. 2008) is multiplied by the total number of households. Dividing this result by the life span, the potential of WEEE expected annually is obtained. Method of consumption and utilization was applied to estimate the flow of WEEE generated (Bureau B & G, 1993),

using the following equation: $WEEE \text{ generated per year} = \frac{m_n \times hh \times r_n}{LS_n}$

m_n : average weight of the equipment n; hh: number of households; r_n : penetration rate of equipment n; LS_n : average life span of the equipment

2 Framework of the study

The field of study includes the entire territory of Benin but with a focus on areas of high transaction and high users' visites. The General Census of Population and Housing allows detailed data to the smallest administrative units on the demographic, economic and socio-cultural population. Important data concerning the people of Benin are presented in the table below.

Table 1: Demographics

Population (2002)	Population Growth	Density	Manpower (2002)
6'769'914 (51.5% women, 48.5% men)	3.25 % (average 1979 – 2002)	59 habitants / km ²	3'065'980

Based on this information, the population growth was extrapolated in the following table.

Table 2: Demographic extrapolation

2002	2010	2012	2025	2042
6'769'914	8'530'092	9'012'163	12'794'155	18'560'594

Youth population in Benin is reflected in the workforce: 61% of the workforce is under 35 years, active seniors of 60 and older account for only 8.4% of the workforce.

2.1 States and markets

The Beninese State has implemented an attractive business environment for the New Technology of Information and Communication (NTIC) in order to have it produce a multiplier effects in all other sectors of the Beninese economy. The result is a growing use of mobile telephony in particular.

Table 3: Information on the telephone

Fixed telephone access	127100, 1.4%
Cellular phone subscribers	5 millions, 56%
Number of internet users	200100, 2.2%

2.2 Products studied

Since it is not possible to study all types of facilities that exist, the present study focuses on the following, deemed very representative of all the flows of WEEE in Benin: Large appliances (refrigerators and freezer), small appliances (heaters - water and iron), telecommunications and computer equipment (TV, computer), video player, stereo, printer, electric shavers, lighting (lamp torch and recharge).

3 political and legal frameworks

Since 2000, Benin adopted policies to initiate development through better use of Information Technologies and Communications. This policy led to the tax and customs exemption on all telecommunications equipment, computer and audiovisual, the establishment of funds to support the development of broadcasting stations, promoting innovations in science, the introduction NTCI in school and education, etc. However, in Benin, there is no specific regulation on the management of WEEE. But this concern finds its essence in the constitution of 11 December 1990 which stipulates in its article 27 that "everyone has the right to a healthy, satisfying and sustainable environment, and has the duty to defend it. The State ensures the protection of the environment.

4 Stakeholder analysis

Unlike industrialized countries that are implementing WEEE management channels economically viable for all classes of equipment, whatever their value, the recycling in developing countries (DCs) is largely dominated by the informal sector, which focuses only on the fraction of waste having economic value in their market. The role of each stakeholder group was analyzed.

- Producers and Importers

Are regarded as producers, any organization that introduces EEE on the market, whether manufacturers or importers. The industrial sector of Benin does not really manufacture EEE. In this context, the import component is predominant.

In the market in Benin the main representatives of imported EEE producers are Hewlett-Packard (HP), TOSHIBA, SHARP, PHILIPS, IBM, DELL FUJITSU SIEMENS COMPUTER and which have subsidiaries in Benin. In addition to these subsidiaries there are importers who deal with the market introduction of products. This is the case of SPACETEL, AFRICAN IMPORT, BENIN - EQUIPMENT, TRADE AFRICA, ATC, ORCA, SEDRIC, SOCAR - BENIN Etc. To these are added the casual who get involved in anything that could make a profit.

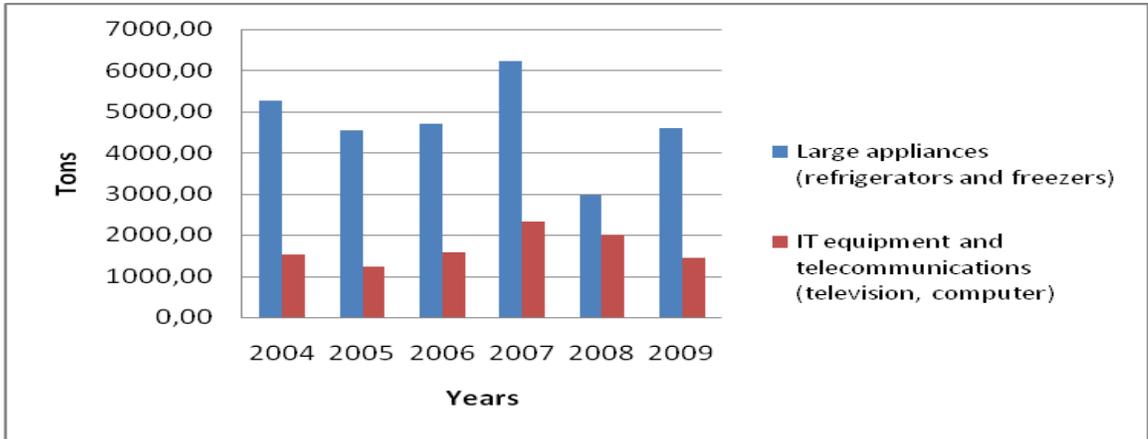


Figure 1a: Weight of equipment (Major household appliances and IT equipment)

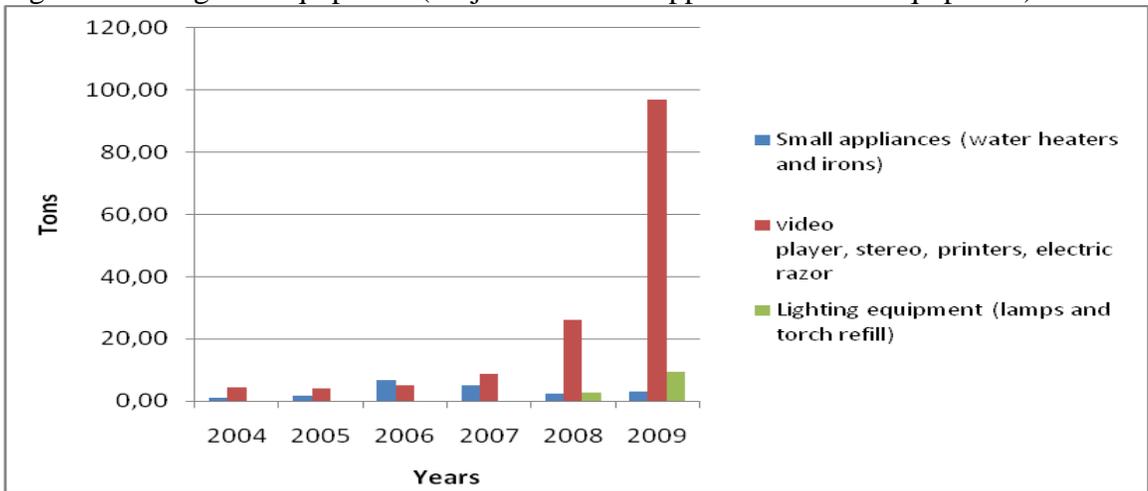


Figure 1b Weight of equipment (equipment Small household appliances major public)

Figure 1: Weight of imported equipment by category

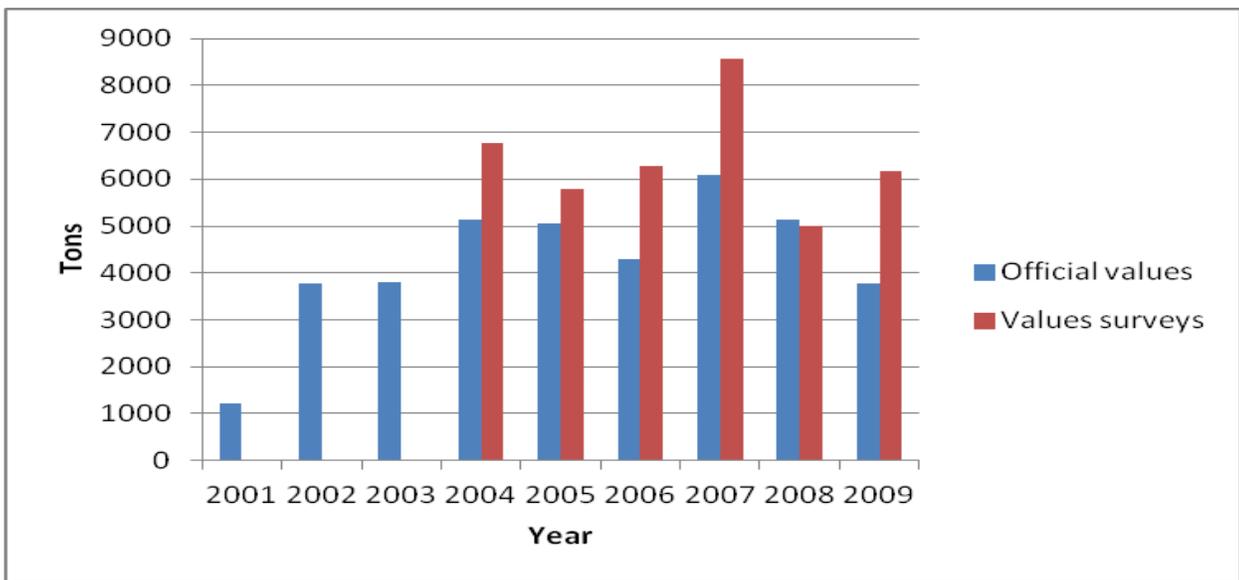


Figure 2 Total weight of equipment

Various surveys show that tons of imported equipment out of service get to Benin to be sometimes directly repaired thrown on landfills and in some cases they are abandoned at the port of Cotonou.

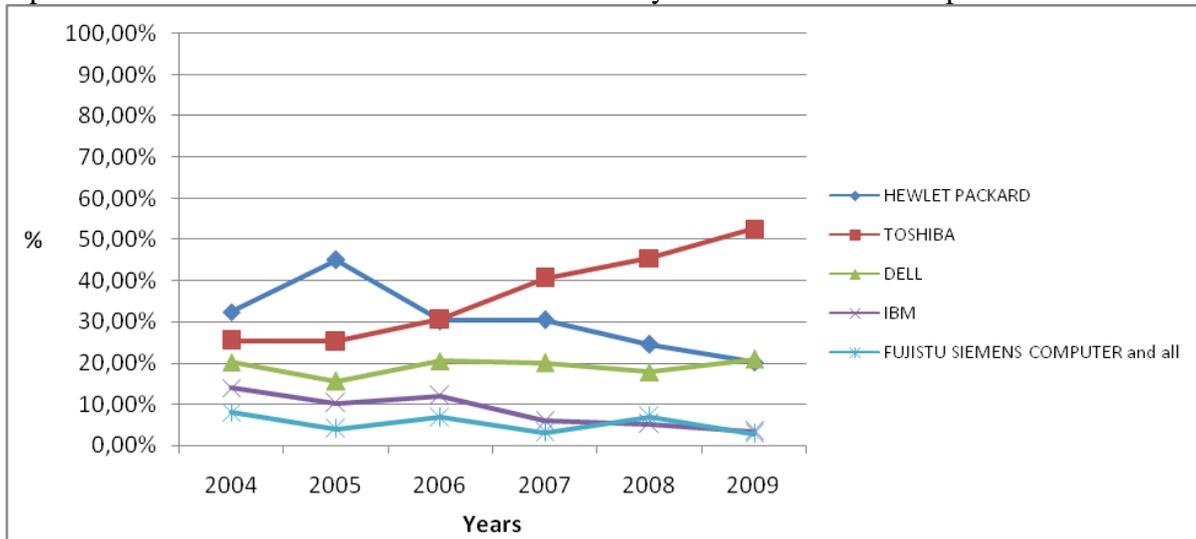


Figure 3: The market share of computer manufacturers - Distributors

Distributors are often commercial companies, regardless of the distribution technique used, including by remote communication, that provide equipment for commercial users. Among the distributors, there are several types including:

- ♣ Wholesalers who are representatives of company like Microsoft (with its many retail distributors) or large business houses like Microland. In this same vein include the Hewlet- Packard (HP).
- ♣ Retail distributors (product specialists at second hand) who sell the bulk of the landings at second hand (computers, printers, televisions).

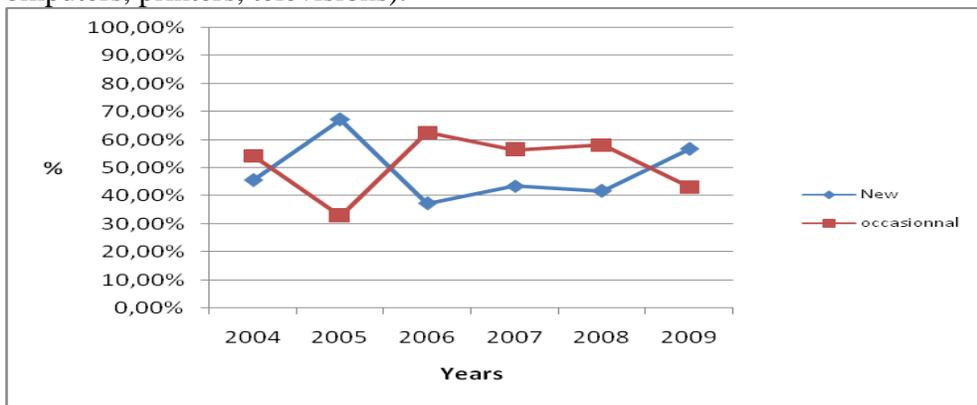


Figure 4: Sales of major appliances by licensed distributors

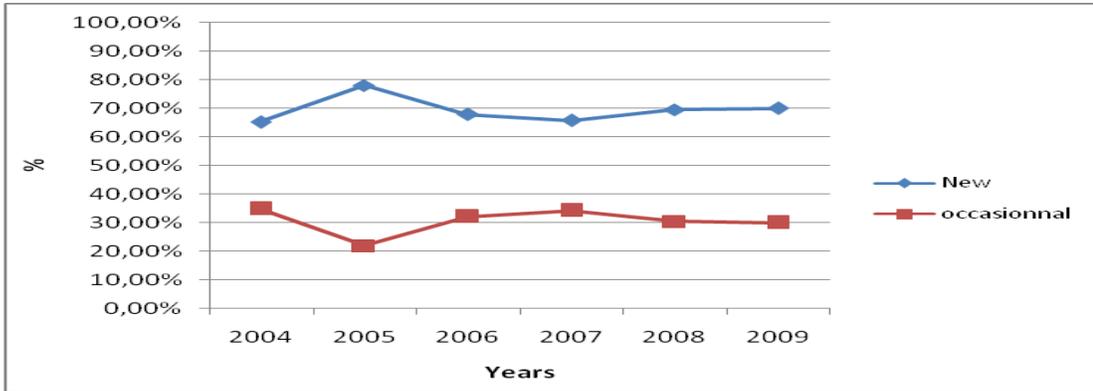


Figure 5: Sales of small appliances

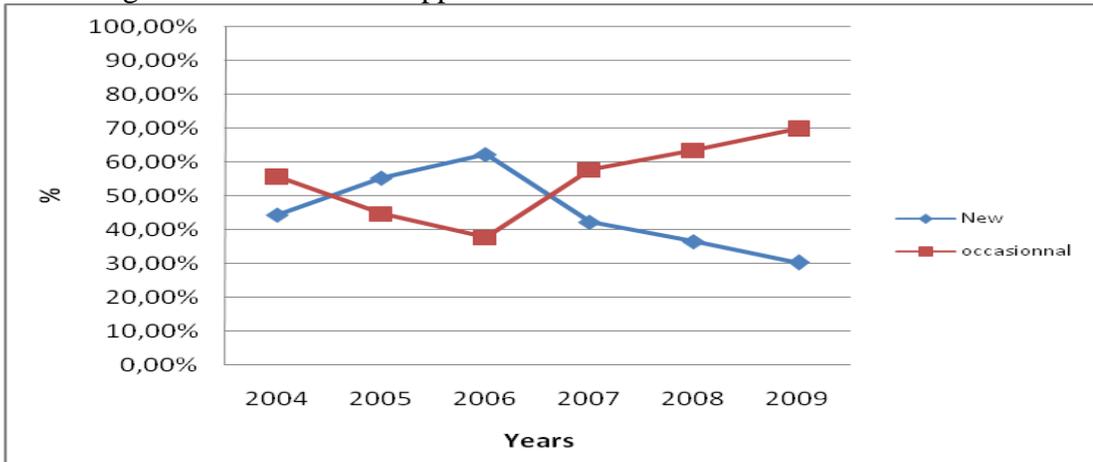


Figure 6: Sale of computer Desks (Fixed)

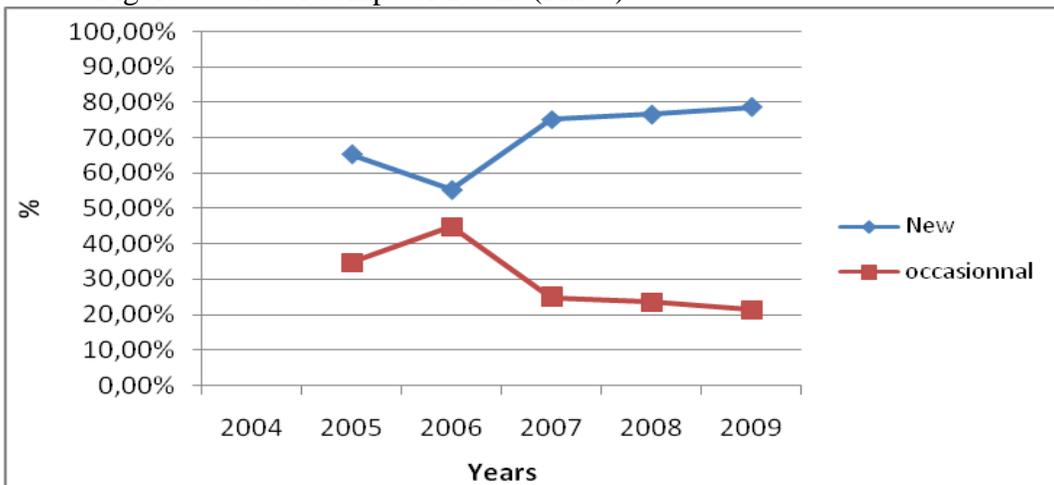


Figure 7: Sales of television sets

The key buyers are students, civil servants, private companies, governments, public enterprises etc. As for Technology Information and Communication (TIC), it is marked in Benin by the presence of the following actors: a fixed network operator (Benin Telecoms SA). This is a public operator, five operators of mobile phone including four private and one public. It is not envisaged in the near future to change this market structure with five operators, Internet service providers and several radio and television.

Table 4: Development and breakdown of the park by mobile phone operator (source: Performance Review of the NTIC sector in Benin and 2010 survey data)

GSM operators	Number of subscribers						
	2003	2004	2005	2006	2007	2008	2009
MTN	139'216	155'000	255'000	450'000	790'097	1'182'014	1'578'786
MOOV	108'766	135'993	175'000	272'106	693'941	978'470	1'357'838
BELL BENIN	7'000	25'000	45'000	172'000	371'576	709'849	849'359
GLO MOBILE	0	0	0	0	0	564'052	1'097'958
LIBERCOM	68'407	73'870	75'000	84'279	196'163	190'843	149'408
TOTAL	323'389	389'863	520'000	978'385	2'051'777	3'625'366	5'033'349

The exponential growth of the mobile phone (GSM) participates in the increase of mobile phones in Benin. Assuming the average weight of a cell phone is 0.2 kg (estimate), we can estimate the weight of telephone in use in Benin. Our investigations show that that one person out of five in has dual SIM phone, and the error would be 16%, that we have minimized in our calculations.

Table 5: Weight of mobile phones

	2003	2004	2005	2006	2007	2008	2009
number	323 389	389 863	520 000	978 385	2 051 777	3 625 366	5 033 349
Weight in tons	64,67	77,97	104,00	195,68	410,35	725,07	1006,67

On the Internet market, there are only eight providers to meet any market demand. According to TARPT the number of subscribers in September 2009 would be for MTN: 105 875, Moov: 22,121, and GLO: 4341 for: a total of 132,337. This number has been known for a large increase especially with the establishment of cyber centers

(Transitional Authority of Regulation of Posts and Telecommunications (TARPT))

- Consumers

• Large consumers

We distinguish the professional sector consumers which include: private companies, research institutes, non-governmental organizations and public enterprises. Surveys show that 31%, 30%, 24% and 15% of business users (computer, cyber etc.) decide to get rid of electric or electronic equipments when they are respectively reduced in efficiency, ageing, broken, outdated or when they buy a new device. Also, 56% of these users have professional repair services and only 25.7% of users say they have recycling systems in their product. Only 5.3% of business users who report having a management service within their service.

Surveys have shown that there is an increasing awareness level of the professional users: 80.6% of them recognize and talk about the environmental risks associated with equipment users, but unfortunately the managing responsibility of these products is still not well known. However 75.5% of these users are willing to lead by example by acquiring technologies for the environmentally sound management of WEEE. Also, 66.6% of users are prepared to help fund research initiatives that support WEEE management, particularly in this case the hardware.

- Small consumers

All households have television sets, DVD players and radio. 70.3% and 29.7% of respondents say they buy these products respectively in the local market and foreign markets. Few users are instructed on the future management of these facilities. 20% of users say that their vendors give them instructions for the management of these facilities. Regarding state of equipment purchased, 44.5%, 48.0% and 7.5% of users say they buy the equipment respectively brand new condition, all second-hand and finally at a state where it is a mixture of a new part and second hand parts. It should be noted that 70% of users said that they buy labeled equipment from vendors but unfortunately these labels still suffer from reliability. As for process management of WEEE, 30.6%, 53.7% and 15.7% of users say respectively that they throw away, repair or give away unusable equipment. About users who routinely throw away, 32% say they mix with other waste WEEE when they throw them to the dumpster. 58.8% of users say they pay for authorized firms who manage the waste discarded equipment. Table below shows the mass of WEEE generated by households.

Table 6: Mass of WEEE generated by households in the form of B & G Office 1993

Equipment	Lifetime	Unit mass (kg)	mass Pénétration	Masse de DEEE (Tons)	Hypothesis
Large appliances (refrigerators and freezers)	8	65	20,00%	983,50	1 household out of 3
Small appliances (water heaters and iron)	2	1	50,00%	90,78	1 household out of 5
IT equipment and telecommunications (television, computer)	5	9,9	25,00%	299,60	1 household out of 3
video player, stereo, printers, electric shaver	3	10	25,00%	302,61	1 household out of 5
Lighting equipment (lamps and torch refill)	1,5	2	16,66%	20,16	1 household out of 20
Mobile phone	2	0,2	50,00%	363,14	4 on average per household
Total weight of electrical and electronic waste				2'059,79	

The total mass of waste that would be generated by households is 2'059, 79 tons.

- Repairers

Repairers are also in the informal sector. They store their equipment under repair or table in a corner of the shop. These facilities are operated in used spare parts as required. The remainder is either sent to wild landfills of the corner. Many repairers (60%) yield materials to recyclers just to rid their store, yield to other means of collecting money.

- Collectors

The majority of collectors is in the informal sector. They are often young foreigners (Maliens, Nigerians, Ghanaians, Nigerians etc.) or from northern Benin. The collection rate is very low, it may be estimated to 10% in taking into account the quantities of waste generated and recovered and the tonnages to be dismantled or to be sold. The informal sector is active and represents most of the chain of collection and recycling of WEEE in terms of quantities and people involved in such activities. The chain of collection and recycling of WEEE is limited to the dismantlement for metal recovery. The waste collection is provided by the following

social groups: the garbage collectors, collectors of discharge, the mobile scrap collectors, brokers, wholesalers.

- Recyclers

Recycling is also highly developed in the informal sector and mostly concerned the recovery and recycling of electronic circuits (diodes, transistors, speaker, resistors, magnet, etc.) and other components such as aluminum, plastic, copper, etc. The extraction of aluminum, copper, bronze, lead from electronic and electrical equipment is the major operations performed on the recycling sites of three major cities of Benin involved in this study (Cotonou, Porto-Novo, Parakou).

- materials recovery valorization

In 2009, nearly 19 358.627 tons of waste and scrap iron were exported to Asia (China, India etc.) and Europe (Belgium, Netherlands, Germany etc.). According to the professional exporters of scrap iron one kg of trash iron is solved at from 125 to 150 FCFA FCFA see. Nonferrous metals are more profitable for exporters. The industry for the recovery of precious metals and special content from WEEE is lacking in Benin.

Table 7: Sectors of materials recovery

Recycled Materials	Recycled in Benin	Possible facilities
Plastic	Yes partially	Yes partially specialized NGOs for recovery of plastics. Artisan specializes in the manufacture of toys and crafts plastic chairs
Metal (iron, copper, etc..)	Yes insufficient	Artisanal, making homes firings by welders, blacksmiths
Aluminium	Yes	Craft (manufacture of stoves and other) / Export to China, India etc. (production of stoves and others) / exportation to China, India etc.
Copper	Yes partially	Export to Europe, china, india
Precious metals (circuit)	No	Export or landfill
Hazardous waste (eg mercury)	No	Landfill, incineration (burned on uncontrolled dumps)
CRTs	No	uncontrolled dumps

- Ultimate treatment

EEE out of order after repeated and unsuccessful repairs undergo no proper treatment in different regions of the country. Note that non-recyclable waste from EEE are kept in the stores, rejected on uncontrolled dumps, buried nearby repair shops or burned. There is no treatment infrastructure of the hazardous fraction of WEEE.

5 Impacts

- Environmental impacts

The various studies and research on the different environmental compartments (air, water, soil, ecosystems) in major urban centers, especially in Cotonou have a lackluster picture on the environmental situation.

The proliferation of EEE represents a risk factor for the environment. The populations in direct contact with WEEE, are susceptible to risks associated with the presence of certain toxic substances in the waste and by hazardous recycling practices. According to UNEP, the WEEE constitute more than 5% of municipal waste worldwide, and constitute the category of waste that the fastest growing development. Environmental issues raised by the wild and primitive "management" of WEEE are water contamination (groundwater, rivers), soil

and air. Unfortunately these WEEE can be found on dumps, around the streets, on the landfill of Ouessè. Some studies have reported significant environmental pollution in many parts of the country. The best known are those that housed the dumps in Cotonou (Agontinkon) and Abomey Calavi (Hêvié). However, direct links are established between the WEEE and heavy metal pollution. Soils and waters contaminated with high levels of heavy metals (cadmium, chromium, lead, mercury ...) and PCBs (polychlorinated biphenyls) (Chouti et al, 2010a and 2010b). Developing countries are not equipped with materials and processing equipment for recovering materials from WEEE. Recycling conditions can be dramatic: a water sample Lianjiang River, near a recycling Chinese village showed lead levels between 190 and 2400 times higher than the standards recommended by the World Health Organization (WHO) and 16 times higher for antimony (BAN et al, 2002). In India, in the absence of proper recycling, 315 million computers will release into the environment 550 million kg of lead, 900,000 kg of cadmium and 180,000 kg of mercury.

- Economic Impacts

Collection of WEEE and recovery of valuable metals from it can be considered as precarious jobs but some of tenants of this type of work make profit out of it. Surveys show that individuals working on the metal recovery from WEEE field are 16% very satisfied, 60% more and less and 24% were not satisfied. . According to these same individuals, the first players in the sector of WEEE is 66%, 20%, 10% and 4% respectively importers, collectors, recyclers and electricians. The sector would benefit most importers / distributors. Scavengers, recyclers, computer scientists and electricians are the second-level players at 40%, 36%, 14% and 10% respectively. As for the actors of the third level, recyclers, computer specialists, electricians and others represent respectively 42%, 36%, 18% and 10%.

The majority of collectors - recyclers (92%) sells the collected items after recycling. 31%, 48%, 19%, and 2% have an average level of daily income, respectively of less than 5000 F, between 5000 and 10000 10000-20000, 20000-and more than 30,000 FCFA. This state of affairs contributes to the integration of unemployed young people and positively impacts the economy. The following table shows the direct contribution of telephony (fixed and mobile) to job creation in Benin.

(1€ = 655,956 FCFA)

Table 8: Direct employment in telephone operators (fixed and mobile) (reference TARPT 2010)

Telephone operator	2006	2007	2008	2009
fixed operator	1'319	1'231	1'114	766
Mobile operators	552	875	1'119	1'210
Total jobs	1'871	2'106	2'233	1'976

Table 9: Annual Turnover (in million FCFA) (reference TARPT)

Telephone operator	2006	2007	2008	2009
fixed operator	33'982	40'618	34'705	10'808
mobile operators	62'262	72'540	118'081	148'911
Overall turnover	96'244	113'158	152'786	159'719

In developing countries and especially in Benin, given the direct and indirect contributions of NTIC in their daily lives, the users, including mobile phone, spend a significant portion of their budget. Indeed, as shown in the following table, the mobile phone users spend, on average, over 3,000 CFA francs per month for consumption with mobile phone service. In March 2009, this consumption is raising up to 3,998 FCFA (Chabossou, 2010).

Conclusions

This study contributed to knowledge flows of EEE and WEEE in Benin. It helped to understand that people in developing countries especially those from Benin, are becoming increasingly aware of the impacts of its activities on the environment. The waste management is no exception to this awareness. The government and some stakeholders as partners in technology development, civil society is gradually establishing systems to manage certain types of waste materials. The import of EEE and WEEE continues despite the Basel Convention and the Bamako Convention which prohibit any transboundary movement of hazardous wastes, resulting in adverse effects on the environment and local people. This is because the second hand EEE are not considered hazardous waste. As for municipal services and NGOs, they do not specialize in the management of WEEE. They collect WEEE as well as domestic and other wastes most of the times all together without any prior sorting from the households. Thus WEEE contents are dispersed in the environment, pollute the environment and have consequences on human health, animal and plant. On the other hand, the reduced lifespan of EEE, between two and eight years on average, leads to high consumption and footprint of the landfill. Dismantling, repackaging and burial of WEEE as waste management practices are observed in the country, but it is clear that all these technologies are still homemade and can not meet the need handling streams of WEEE. Finally the ultimate end point for this waste is landfilling.

References

BAN & COALITION, (2002). Exporting Harm – The high-tech trashing of Asia. The Basel Action Network and Silicon Valley Toxics Coalition. <http://www.ban.org>.

BECK M., (2004). A feast for bureaucrats, protectionists and environmental fundamentalists. *Recycl Inc.* p. 16–21.

BRODERSEN K., TARTLER D., BERGMANN HW., WERNER GD., EDER S., (1992). Scrap of electronics; hazardous waste or raw material resource? In: the ASM European Office, editor. Proceedings of the 1992 conference on the recycling of metals, the European Council of ASM International and its Technical Committee. Belgium: ASM; p. 45–51.

BUREAU B., (1993). Analyse document Projet kt Wit-fr Bruinngloed (Achtgrond-document). Rotterdam

CLEAN JAPAN CENTER., (2002). Tokyo, Japan: Recycling-Oriented Society.

CHABOSSOU A., 2010. Revue de Performance du Secteur des TIC Benin 2009/2010 *Towards Evidence-based ICT Policy and Regulation Volume Two*. 20 p

CHOUTI W., MAMA D., ALAPINI F., (2010 a) Etude des variations spatio temporelles de la pollution des eaux de la lagune de Porto Novo (Sud Bénin) *International Journal of Biological and Chemical Science* 4 (4) : 1017 – 1019 ISSN 1991- 8631

CHOUTI W., MAMA D., CHANGOTADE O., ALAPINI F., BOUKARI M., (2010 b) Etude des éléments traces métalliques contenus dans les sédiments de la lagune de Porto Novo (Sud (Bénin). *Journal of Applied Biosciences* 34 : 2186 – 2197. ISSN 1997 – 5902.

DENG WJ, LOUIE PKK, LIU WK, BI XH, FU JM, WONG MH. (2006). Atmospheric levels and cytotoxicity of PAHs and heavy metals in TSP and PM_{2.5} at an electronic waste recycling site in southeast China. *Atmospheric Environment*;40:6945–55.

HUISMAN, J., MAGALINI F., (2008). Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), Final Report, United Nations University

LaCOURSIÈRE C., (2005) Electronic waste recovery business (E-128). Norwalk, CT, USA: Business Communication Company Inc. (BCC)

LEE K. M., (2005). Eco-design and electronics waste recycling. In: International symposium on e-waste recycling coping with WEEE & RoHS. Daejeon, Korea: KIGAM

PANATE M. (2009) Extended producer responsibility in a non-OECD context: The management of waste electrical and electronic equipment in India. *Resources, Conservation and Recycling* 53 : 136–144

Kang H-Y, Schoenung JM. (2005) Electronic waste recycling: a review of U.S. infrastructure and technology options. *Resources, Conservation Recycling* 45:368–400.

SCHWAZER S., De BONO A., GIULIANI G., (2005). Les Déchets Electroniques, la face cachée de l'ascension des technologies de l'information et de la communication, Pré-alertes sur les menaces environnementales émergentes. *Bulletin du PNUE*, 4 p

WANG D., CAI Z., JIANG G., LEUANG A., WONG MH., WONG WK., (2005). Determination of polybrominated diphenyl ethers in soil and sediment from an electronic waste recycling facility. *Chemosphere*; 60:810–6.

WONG CSC., WU SC., DUZGOREN-AYDIN NS., AYDIN A., WONG MH., (2007). Trace metal contamination of sediments in an e-waste processing village in China. *Environmental Pollution*; 145:434–42.

YU XZ., GAO Y., WU SC., ZHANG HB., CHEUNG KC., WONG MH., (2006). Distribution of polycyclic aromatic hydrocarbons in soils at Guiyu area of China, affected by recycling of electronic waste using primitive technologies. *Chemosphere*; 65: 1500–9.