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1. INTRODUCTION

This report forms a further basis to achieve the general objective of WP 3, which is to provide the West African stakeholders with tools to implement Integrated Solid Waste Management Systems (ISWMS) adapted to regional conditions in their countries. Subsequently, best practices in Europe and non European countries were identified by a broad range of members of the project team.

To this aim in chapter 2 of this report experiences with ISWM in Europe are described regarding logistical, technological, legal and organisational aspects. In chapter 3 experiences with ISWM in Africa as well as examples of successful ISWM systems already implemented are presented. Finally, in chapter 3 a summary of the experiences with substance bans in EU waste legislation is presented, such as the Restriction of Hazardous Substances Directive (RoHS) for electrical and electronics equipment.

2. EXPERIENCES OF ISWM IN EUROPE

2.1. Examples from Netherlands (Belgium)

2.1.1. General Waste Policy in the Netherlands

The Netherlands is one of the few countries in the world that has so complete and multifaceted waste-processing infrastructure. For many years now, the country has been one of the leaders in Europe with regards to waste practices modernization.

The most popular environmental measure in the Netherlands is waste separation. More than 90% of the people separate their household waste, which makes this practice the most popular and widely used measure.

Due to the well developed waste management structure, no less than 64% of the municipal waste has been recycled in the Netherlands. The country is practically unique in terms of recycling as much waste, and in addition most of the residual waste is incinerated to produce electricity, resulting in only small percentage of waste being disposed off at landfills.

The unique approach that has been developed through the years consists in avoiding to produce waste as much as possible, trying to recover all valuable raw materials from any waste that is created, trying to produce energy by burning the residual waste, and only after all of the above mentioned practices have been applied disposing what has left over in an environmentally friendly way. In cases when waste cannot be prevented, as much as possible of it should be recycled. However, non-recyclable waste should be taken care of in a way, such that the risks it may create to the environment are acceptable. Those waste practices are the cornerstones of the Dutch waste policy. This approach has been integrated into the country's legislation in 1994 and is known as "Lansink's Ladder". It has been recently included in the European Waste Framework Directive.

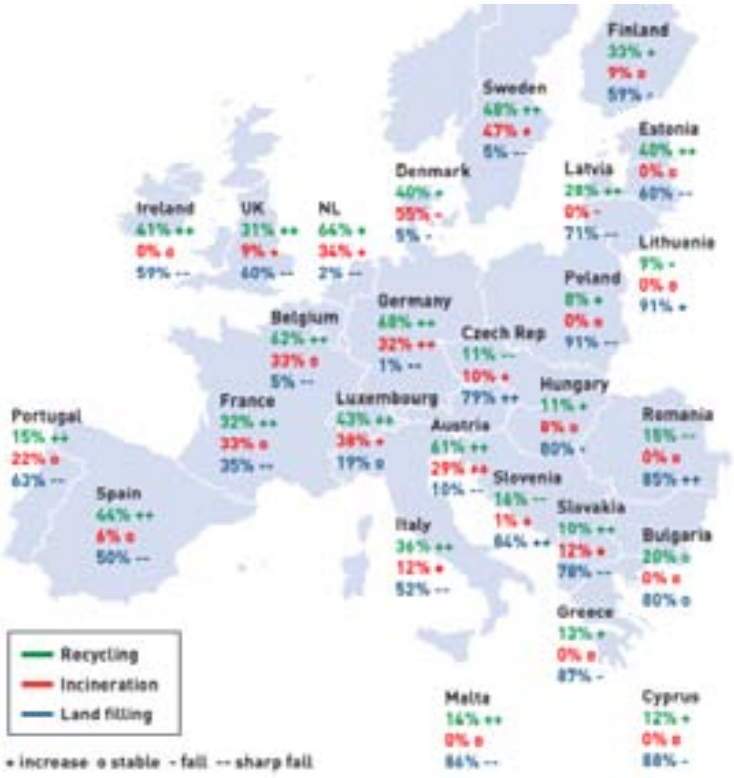

Fig. 1: Processing of urban waste in Europe and the trends in recent years (Eurostat, 2006)

2.1.2. The Dutch Waste Profile

The Netherlands has an area of 41,848 km^2 and population of 16,659,100 inhabitants (Data: 2011 estimate)[1]. The total GDP of the Netherlands for 2010 is estimated to be 676,700 billion $ where the GDP per capita is 40,777 $. The environmental costs amount to 2.5% of the GDP (corresponding to 10 billion €) where the total costs of waste management in the country are 4.1 billion € which correspond to 41% of the budget allocated for environmental costs. For comparison, Senegal's total area is 196,723 km^2, has a population of 13,711,597 inhabitants (data for 2009). The total GDP of the country for 2010 is 23,274 billion $ where the GDP per capita is 1,772 $.

Waste policies

Back in the 1990s, the key to successful development of waste management was based on the cooperation between local, provincial and national government. Those three authorities reached a consensus to implement waste management programs and to comply with all agreements issued by the council, thus guaranteeing common responsibility and reliance for the planning and implementation of decisions.

However, recycling and prevention of waste generation needed to be promoted due to area constraints in the country. These practices were strongly stimulated as extra landfill capacity and large-scale incineration were needed for the upcoming years, which from the other hand would result in large investments.

Nevertheless, this policy could not be implemented given the existing provincial and municipal municipalities. The government had to establish few national plans additionally as reaching a common agreement on new policies and disposal facilities requires close cooperation between all institutional bodies which are involved.

In the past times, waste management has been responsibility of the local authorities and each municipality had its own landfill whereas some large cities had their own incineration plants due to lack of space for landfilling. In 1976/1977 the "Hazardous Waste Act" and "Waste Act" were introduced by the government with the main goal to decrease significantly the amount of waste being dumped on landfills which was resulting in great environmental problems. Consequently, waste disposal needed to be organized on a larger scale in order for the technical provisions to be economically justifiable.

However, lack of administrative scale for handling waste in an environmentally friendly and hygienic way at reasonable costs was still lacking until 1993 when the Environmental Management Act came into force enclosing waste management. In addition to that, public awareness has been motivated making it known to the producers that they have their own responsibility with regards to the management of the products they sell when the waste stage is reached, i.e. some or all of the waste management costs should be included in the price of the product.

Landfill tax was also introduced in order to make landfilling more expensive than the alternative treatment ways. In addition, the Landfill Decree and the Landfill (Aftercare) Act have been introduced into the system of waste management. This practice was needed as the composition and the volume of waste going to landfills have been completely changed and sharply declined. Based on the Waste Decree changes were made into the list of wastes allowed for landfilling.

Lansink's Ladder

The principle which this waste management hierarchy represents is following a specific order of preference which implies that prevention is the most preferred option while landfilling of waste is the least preferred one, as described in the Environmental Management Act.

Due to the space requirements which apply for the country, the amount of waste going to the landfill should be minimized. It is important to be underlined that landfills correspond only to 35% of all methane emissions for the country. As methane stands for only 15% of the greenhouse effect, it

[1] Source: Waste Management Authority of SenteNovem

results that landfills are responsible for only 5% of the total greenhouse gas effect of the Netherlands.

The figure below represents the waste management hierarchy of the Lansink's Ladder on which the Dutch waste policy is based.

Fig. 2: Waste Hierarchy in the Netherlands, Lansink's Ladder (Made in Holland. October 2008)

Based on the above illustrated waste management approach, the Dutch waste policy involves[2]:

- devising and adopting instruments to encourage of enforce prevention and recycling and reduce the waste going to landfill
- setting environmental and policy constraints for waste management
- creating a framework for waste management planning at national level
- spelling out the responsibilities of producers for the disposal of their products in the waste phase
- regulating imports and exports of waste

Number of instruments have been developed, both regulatory and non-regulatory, to encourage waste prevention and to raise awareness among the public with regards to waste generation. In the case of industrial waste, these instruments represent a specific section of integrated set of measures, among which are energy and water conservation. These are compiled in an implementation program developed by the Association of Provincial Authorities, the Association of Netherlands Municipalities and the Ministry of Housing, Spatial Planning and the Environment. Financial instruments, such as the landfill tax additionally promote decreasing of waste generation and discourage landfill practices.

Various instruments have also been developed with the main goal to promote product and material recycling. The Environmental Management Act requires local authorities to establish systems for the separate collection of kitchen and garden waste from households. As part of the new waste management plan some constraints to waste management have been applied. One of them is the "Prohibition of Landfill" Waste Substances Decree, which bans the landfilling of wastes when recycling or incineration of the same wastes is possible.

The 1993 Waste Incinerators (Air Emissions) Decree contains standards and regulations relating to atmospheric emissions, the combustion process, monitoring and record-keeping. Requirements as

[2] **Source:** Ministry of Housing, Spatial Planning and the Environment; June 2011, Factsheet

to the quality of secondary raw materials produced from waste are laid down in the Building Materials Decree, the Other Organic Fertilizers (Quality and Use) Decree and the Fuels (Organic Halogen Content) Decree. Requirements for landfill establishments are laid down in the Landfill Decree (Soil Protection Act).

According to the National Waste Management Plan, the objectives regarding waste management practices for 2012 are to be increased the relative unlinking that has already been achieved of the GDP including the total waste supply by continuing and intensifying the prevention policy; the level of waste recovery should be increased up to 83%, and limiting the amount of waste for disposal to 9.5 billion kg from which only 2 billion kg should be waste for landfilling.

2.1.3. Solid Waste Management Practices in Rotterdam

Rotterdam is the second largest city in the Netherlands located in the Province of South Holland. The city is also Europe's largest port. Rotterdam is also known for its modern architecture as after the city center has been completely destroyed after the World War II, it has been reconstructed leaving almost no old buildings.

Rotterdam has a size of 319 km^2, population of 611,000 inhabitants whereas the urban area comprises almost 2,100,000 inhabitants (data for October 2010). The average household size is 1.95 and the human development index for 2009 is estimated to be 0.964.

Based on the growing environmental attentiveness among the people and on the increasing awareness to preserve as much as possible the resource values of the generated waste, national policy framework aiming to reduce the landfilling practices and to increase the materials and energy recovery has been developed. Rotterdam optimizes its energy recovery putting a strong emphasis on recycling, composting and prevention.

The municipal waste management department in Rotterdam is responsible for the collection of waste from commercial zones and household waste on a weekly basis. This process operates applying either one (plastic bag, 240 liter container), two (plastic bag, 1,100 liter container) or three ($3m^3$, $4m^3$, and $5m^3$ underground containers) collection services per week.

National policy goals regarding recycling and waste minimization are established in the recently updated National Waste Management Plan for the period 2009-2021. The producers finance their obligations via advanced disposal fees (batteries, white and brown goods, automobiles) or direct producer payments (waste electrical and electronic equipment, paper and packaging). In Rotterdam, the following waste streams are separately collected though depots, drop-off containers or house-to-house collection, and transported directly, without transfer, to upgrading/recycling enterprises (Fransen et al., 2008).

2.2. Examples from Spain

2.2.1. SPANISH SOLID WASTE COLLECTIVE MANAGEMENT SYSTEMS

In response to collection and recovery targets of several European and Spanish regulations on specific waste streams, different collective take-back systems have been organized in Spain with the aim of helping stakeholders to fulfil the law. In general, the integrated waste management systems are not-for-profit organizations open to the voluntary participation of the economic operators (producers, distributors) of the sector concerned and also to the participation of the competent public authorities.

Collective take-back systems with active stakeholder management provide a sound basis for moving forward, both at the European and national levels, with efficient and cost-effective system for collection and recovery of a waste type. They offer the simplest, most straightforward and cost-effective approach, besides they place manufacturers in a key role as the primary managers of the recycling infrastructure through governance of the management entity.

Their activities include the following:

- Take on the legal obligations of producers

- Manage the data collection and reporting
- Negotiate contracts with operators
- Arrange logistics
- Arrange recycling
- Manage the financing
- Maintain the audit trails

Taking into account the scope of the IWWA Project, in

Table 1 the collective take-back systems established in Spain for solid waste stream are listed. These integrated management systems are focused on post-consume waste of household packaging (plastic, glass, metal and paper/cardboard), Phytosanitary packaging, medicinal packaging and unused household medicines, waste electrical and electronic equipment, batteries and accumulators, lighting systems, lamps and used tyres.

Table 1. List of Spanish solid waste collective management systems

Spanish name	Web site	Type of waste
Ecoembalajes España, S.A. (ECOEMBES)	www.ecoembes.es	Household light packaging (plastic, metal, tetra-brik) and paper/cardboard
Ecovidrio	www.ecovidrio.es	Glass packaging
Sigfito Agroenvases, S.L. (SIGFITO)	www.sigfito.es	Phytosanitary packaging
Sigre Medicamento y Medioambiente (SIGRE)	www.sigre.es	Medicinal packaging and unused household medicines
Eco-Raee's Foundation	www.eco-raee.com	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC categories: 1, 2, 3, 4, 5, 6, 8, 9 and 10 Spanish law (Royal Decree 106/2008 on batteries and accumulators and its appropriate waste management): used batteries and accumulators
Ecolec Foundation	www.ecolec.es (not available at this moment)	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC categories: 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10
Ecoasimelec Foundation	www.ecoasimelec.es	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC categories: 1, 2, 3, 4, 6, 7, 8, 9 and 10

Ecofimática Foundation	www.ecofimatica.es	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC category 3 (printer systems, fax.). No toner or ink cartridges.
Ecopilas Foundation	www.ecopilas.es	Used batteries and accumulators
Tragamóvil Foundation	www.tragamovil.es	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC category 3 (mainly cellular telephones and accessories)
Ecotic Foundation	www.ecotic.es	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC: - Categories: 1, 2, 3, 4, 6, 7, 8 and 9 for domestic appliances. - Categories: 1, 2, 3, 4, 6, 7, 8, 9, and 10 for professional appliances.
European Recycling Platform España (ERP – España)	www.erp-recycling.es	Waste electrical and electronic equipment (WEEE). Directive 2002/96/EC: - Categories: 1, 2, 3, 4, 6, 7, 8, 9 and 10 Spanish law (Royal Decree 106/2008 on batteries and accumulators and its appropriate waste management): used batteries and accumulators
Asociación para el Reciclaje de Lámparas (AMBILAMP)	www.ambilamp.es	Category 5 (Directive 2002/96/EC): Lighting systems, lamps
Ecolum Foundation	www.ecolum.es	Category 5 (Directive 2002/96/EC): Lighting systems, lamps
Sistema Integrado de Gestión de Neumáticos Usados (SIGNUS)	www.signus.es	End-of-life tyres

The specific features of every Spanish collective take-back systems are summarised below:

2.2.2. Ecoembalajes España, S.A. – ECOEMBES [Example 1]

2.2.2.1. Legal elements

ECOEMBES is a not-for-profit organization, whose corporate purpose is to design and develop systems focussed on selective collection and recovery of packaging waste with the objective to fulfil the prevention, recycling and recovery targets established in the Spanish waste legislation (transposition of European Directive 94/62/EC on packaging and waste packaging and its modifications):

- Spanish Law 11/1997, 24 April, on packaging and packaging waste
- Royal Decree 798/1998, 30 April, on regulations to develop the Law 11/1997

2.2.2.2. Organisational elements

ECOEMBES, as the managing entity of a collective take-back system, guarantees periodic selective collection and recovery of all packaging waste generated by member companies (packager, commerce and distribution, raw material and recyclers group), in accordance with the spirit and purpose of said Law. Currently, this collective take-back system has authorisation to operate in all Spanish regions. ECOEMBES is financed by contributions that it receives from member companies. Each company pays a fee for the packaging of each product that it places on the Spanish market.

2.2.2.3. Logistical elements

ECOEMBES collaborates with municipal authorities in selective collection, transport and handling, and in the subsequent upgrading, recycling and recovery of packaging waste, conveniently separated by materials, and finances the extra cost resulting for said separation. The extra cost is the difference between the ordinary collection, transportation and treatment system of waste and solid waste, and the current system necessary to comply with the law, for which is necessary to update the existing infrastructure and to acquire new vehicles.

The packaging included in the ECOEMBES integrated waste management system must be identified by means of an accreditation symbol called “green point”. This symbol belongs to ECOEMBES and guarantees that companies whose packaging carry this logo, fulfil with their obligations established in the Law through this collective take-back system. ECOEMBES manages the correct collection and recovery of packaging waste made of metals, rigid and film plastics, brik and paper/cardboard.

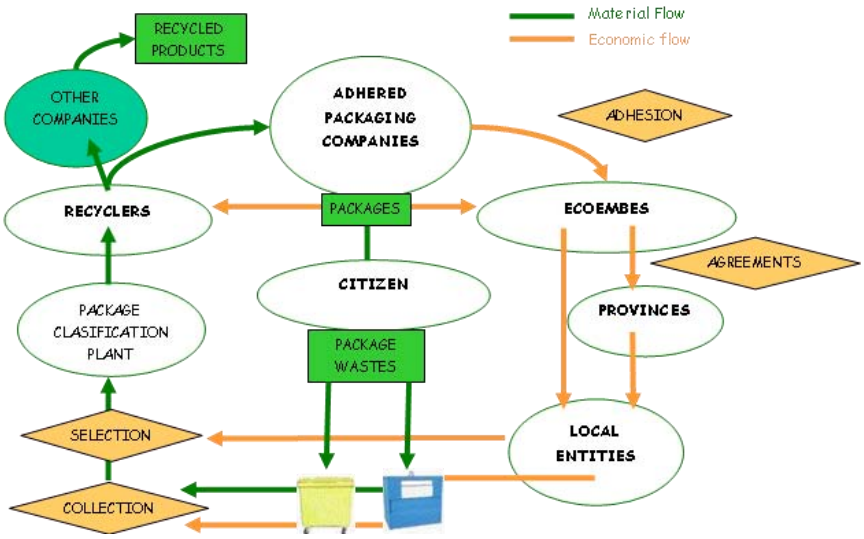

Fig. 3: ECOEMBES integrated management system

2.2.2.4. Technological elements

Citizens can deposit their household light packaging waste in the specific containers placed in the streets. There are two types of containers depending on the packaging waste type:

- Yellow container for plastic, metal and brik packaging.
- Blue container for paper and cardboard.

Fig. 4: ECOEMBES containers and collection vehicle

Some data are indicated as follows:

- Members of ECOEMBES in 2009: 12,175 companies (90% of packaging put on the market in Spain).
- Amount of packaging commercializes in Spain (2009): 1,894,213 t
- Due to agreements with different authorities, by the end of 2009 ECOEMBES is accessible for 98.5% of Spanish people: 44.9 millions of citizens have yellow containers and 45.3 millions have the blue ones.
- Collected waste: 33.7 kg/inhabitant per year
- More than 11 millions of tonnes of packaging recovered since ECOEMBES started the activity.

2.2.3. Ecovidrio [Example 2]

2.2.3.1. Legal and organizational elements

ECOVIDRIO is a not-for-profit organization focused on glass packaging waste management in Spain. All sectors involved in glass recycling are represented: packagers, manufacturer and recyclers. ECOVIDRIO is funded by packers according to the amount of glass packaging put on the market for each one. In order to fulfil the legislation, ECOVIDRIO carries out the selective collection of used glass packaging and guarantees a correct recycling of the material. It also informs to citizens about glass packaging waste management in order to get their collaboration in this task. The legal background is:

- Spanish Law 11/1997, 24 April, on packaging and packaging waste
- Royal Decree 798/1998, 30 April, on regulations to develop the Law 11/1997

The companies joined to ECOVIDRIO can use the “green point symbol” in their products due to an existing agreement between ECOEMBES and ECOVIDRIO.

2.2.3.2. Logistical and technological elements

The final consumers can throw their glass packaging waste into the ECOVIDRIO green containers placed in the streets. In these containers only glass from packaging must be disposed (mainly jars and bottles), avoiding other waste of glass.

Table 2: Recycled glass collected in green containers

Year	Glass collected, t	Kg/inhabitant
2008	716,203,655	15.42
2007	657,329,716	14.54
2006	576,967,644	12.90
2005	513,301,531	11.64
2004	468,511,925	10.64
2003	435,318,219	9.98
2002	397,930,313	9.23
2001	358,005,234	8.68

2.2.4. Sigfito Agroenvases, S.L. – SIGFITO [Example 3]

2.2.4.1. Legal and organizational elements

SIGFITO Agroenvases, S.L. is a not-for-profit society created to organize a collective take-back system for phytosanitary packaging residues in order to subject them to an environmental friendly treatment. It collects plastic, paper and cardboard and metallic phytosanitary containers since year 2003. SIGFITO was an initiative of producers and packers of phytosanitary products in order to fulfill the legislation in aspects related to collection and recovery of their end-of-life containers (mainly, Spanish Law 11/1997, of 24 April, on Packaging and Packaging Waste and Royal Decree 1416/2001 of 14 December, on packaging of phytosanitary products). Once a company is joined to this collective take-back system, SIGFITO is releasing it from legal responsibilities on packaging waste management. Thus, the main purpose of SIGFITO is to facilitate to the involved stakeholders (producers, packers, retailers and farmers) the law performance in the management of this waste type.

2.2.4.2. Logistical and technological elements

During year 2008, SIGFITO collected 2.860 t waste phytosanitary containers (83.9% plastic, 9.0% paper and cardboard, 6.5% metallic and 0.6% others) and claimed 87.2% recycling, 4.4% energy recovery, 8.1% disposal and 0.3% not specified management.

Table 3. Collection of phytosanitary packaging waste in Spain by SIGFITO

	2003	2004	2005	2006	2007	2008	2009
Packages joined to the system, t	6,602	6,672	6,136	6,279	6,352	6,041	5,598
Waste packages collected, t	337	1,073	1,445	2,041	2,660	2,860	2,688
Waste packages collected, %	5.1%	16.1%	23.5%	32.5%	41.9%	47.3%	48.0%

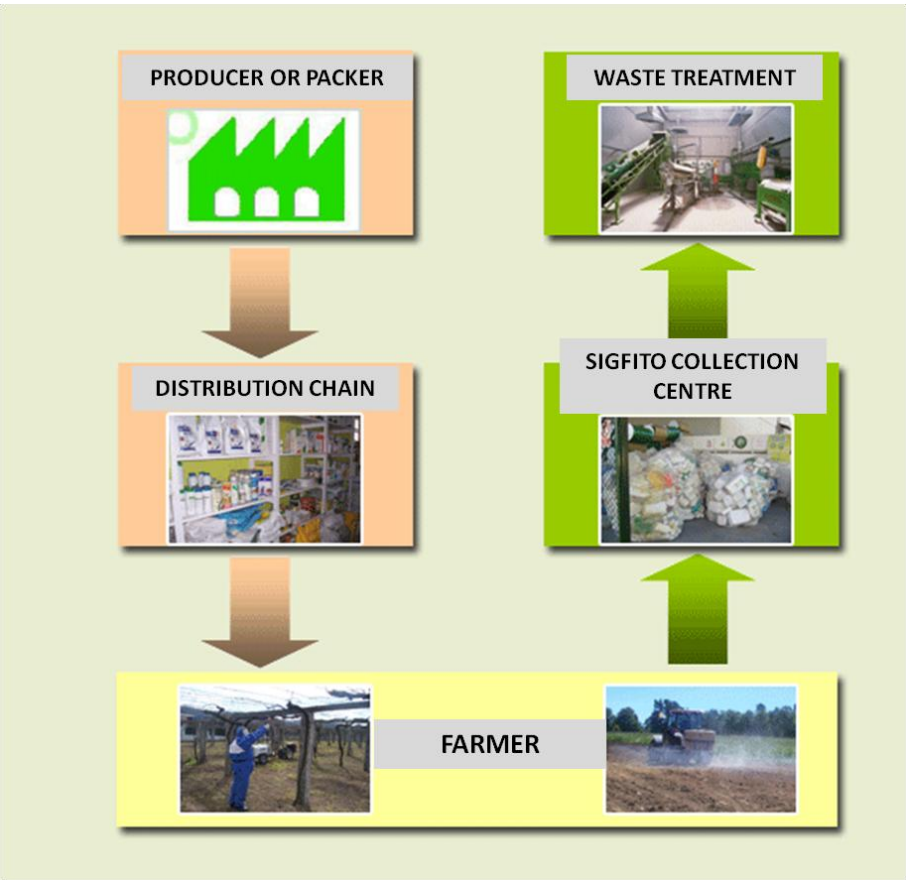

Fig. 5: SIGFITO scheme

2.2.5. Sigre Medicamento y Medioambiente – SIGRE [Example 4]

2.2.5.1. Organizational elements

SIGRE Medicamento y Medio Ambiente is a not-for-profit organisation set up to guarantee proper environmental management of medicinal packaging and unused household medicines. The original idea was promoted by pharmaceutical laboratories in 2001 and pharmacies and pharmaceutical distribution companies play an active role in the organisation. The membership of SIGRE comprises the main institutions representing the different actors in the medicine chain:

- National Corporate Association of the Pharmaceutical Industry (Farmaindustria).
- General Board of Official Pharmacists' Associations (CGCOF).
- National Federation of Associations of Wholesale Distributors of Pharmaceutical Specialities (FEDIFAR).

SIGRE acts on two fronts:

- Environmental: reducing the environmental damage caused by packaging and unused medicines via waste prevention at source and the proper environmental treatment of waste generated.
- Health: stopping medicines from accumulating in the home and raising public awareness about the health risks related to the improper use of these medicines.

2.2.5.2. Logistical and technological elements

SIGRE was designed as a closed management system based on inverse logistics involving the different players in the medicine chain. The first stage of SIGRE's activity involves collecting unused medicines that are left in special containers called “Punto SIGRE” located in pharmacies. The containers are for consumers to deposit unused or expired medicines and their empty packaging. Next, pharmaceutical distributors collect the unused medicines and store them at their facilities in water-tight containers, which are later removed by authorised waste managers to be taken to the Unused Medicines Classification Plant in Cerceda (A Coruña, Spain). In this plant, unused medicines are classified before being sent to authorise waste managers to be subjected to their final treatment.

Two types of checks are applied to the scheme implemented by SIGRE to guarantee the control and safety of each phase of this process. Firstly, checks are performed on the various parties in the system under the legislation in force, and then further checks established directly by SIGRE are made to guarantee the smooth running of the system.

Thus, in addition of the checks performed by the environmental and health authorities (processing licences, gathering information or making inspections), SIGRE has established a series of direct checks to guarantee that the different players in the system are doing their job correctly - audits, application of technical instructions, safety guidelines, traceability of the waste, etc. - whilst adhering to the UNE-EN ISO 9001:2008 standards on Quality Management Systems; UNE-EN ISO 14001:2004 on Environmental Management Systems and OHSAS 18.001:2007 specifications on Occupational Health and Safety Management Systems.

All medicine packaging sold in pharmacies in Spain carries the SIGRE symbol to inform the consumer that the product is covered by this integrated management system. The SIGRE symbol is authorised by the Spanish Medicines and Healthcare Products Agency (AEMPS) and by the European Medicines Agency (EMA). By including the SIGRE symbol on their labels, pharmaceutical laboratories are meeting both environmental and healthcare regulations.

The SIGRE scheme has been implemented all over Spain and is therefore authorised by the Regional Environment Ministries of the various Autonomous Communities and cities. These administrations are responsible for supervising the correct management of unused medicines.

2.2.5.3. Legal elements

- Main environmental legislation:
  - Spanish Law 11/1997, of 24 April, on Packaging and Packaging Waste
  - Spanish Law 10/1998, of 21 April, on Waste
  - European Waste Framework Directive 2008/98/EC
- Main health legislation:
  - Spanish Law 29/2006, of 26 July, on Guarantee and Rational Use of Medicines and Health Products
  - Royal Decree 1345/2007, of 11 October, for regulation of the procedure of authorisation, registration and sale conditions of the medicines manufactured industrially for human consumption.

2.2.6. Eco-Raee's Foundation [Example 5]

2.2.6.1. Legal and organizational elements

ECO-RAEE is an environmental foundation, not-for-profit organization, founded by manufacturers and importers of electrical and electronic equipment. ECO-RAEE is a Spanish integrated waste management scheme for waste electric and electronic equipment whose main objective is to insure all manufacturers and importers of electronic and electrical appliances affected by the Royal Decree 208/2005 of 25 February on electric and electronic equipment and its appropriate waste management (transposition of European Directives 2002/96/EC and 2002/95/EC). Likewise, as a not-for-profit organization, all incomes are assigned for the properly collection and recovery of waste of electronic and electrical appliances generated by the members, and to accomplish the principles and liabilities of law.

2.2.6.2. Logistical and technological elements

Some services offered to the members of the Foundation are listed below:

- Technical and Legal Adviser
- Logistic for the delivery of recipients for collection, trucking and treatment of waste.
- Value of waste whenever there is price in the market
- Computer system through the web site for the proper collection and transportation of waste belonging to the foundation members till the recovery plants.
- Inscription of the members in the Ministry of Industry, Tourism and Trade, and also the Registration in the Spanish Communities.
- Accomplishment of RoHS Directive 2002/95/EC, and replacement of dangerous components in electronic and electrical devices.

The following categories of electrical and electronic equipment are covered by ECO-RAEE:

- Category 1 - Large Household Appliances
- Category 2 - Small Household Appliances
- Category 3 - IT and telecommunications equipment
- Category 4 - Consumer equipment
- Category 5 - Lighting equipment
- Category 6 - Electrical & Electronic Tools
- Category 8 – Medical devices
- Category 9 – Monitoring and Control instruments (fully covered)
- Category 10 - Automatic Dispensers

2.2.6.3. Legal elements

Later, ECO-RAEE extended its areas of action to used batteries with the entry in force of Spanish Royal Decree 106/2008 of February fist, on batteries and accumulators and their environmental waste management (transposition of European Directive 2006/66/EC).

2.2.7. Ecolec Foundation [Example 6]

2.2.7.1. Organizational elements

The Ecolec Foundation has been created in 2006 as a WEEE take-back collective management system set up by the business associations that represent the manufacturing sector and importers of large and small electrical appliances (as of January 2007, it has over 170 members). By taking advantage of existing structures and markets, Ecolec offers a model of management for waste electrical and electronic equipment which encourages and guarantees strict compliance with the regulations.

2.2.7.2. Logistical and technological elements

The collection system of Ecolec relies on the following collection points:

- Municipal facilities actually approximately 700 points in all Spain.
- Retailers working with Ecolec are approximately 380 different points, for the direct collection.
- There are other 100 points of collection, formed by de waste companies in collaboration with Ecolec.

All the WEEE collected in these points, are transported to a main collection facilities or directly to the waste management companies. These operations are optimized by a logistic partner for all Spain. The collection system is especially complex for the different islands of Spain, where the waste companies work co-ordinately with the logistic partner to deliver the WEEE to the treatment plants in the mainland. There are plans to run treatment plants in the islands.

Ecolec has a logistic partner that gives service for all the regions inside Spain. This partner makes collection services through Ecolec computer System, using collection requests. This main partner has actually 13 main warehouses in all the country.

Ecolec has other 60 waste companies that collect in different points along the country. These companies apply programmed collection for different retailers or users. This collection is part of the traditional scrap collection system. Regarding the treatment partners, Ecolec has approximately 25 treatment partners for different categories. The categories of electrical and electronic equipment covered by Ecolec are:

- Category 1 - Large Household Appliances (fully covered)
- Category 2 - Small Household Appliances (fully covered)
- Category 3 - IT and telecommunications equipment (fully covered)
- Category 4 - Consumer equipment (fully covered)
- Category 5 - Lighting equipment (fully covered)
- Category 6 - Electrical & Electronic Tools (fully covered)
- Category 7 – Toys, leisure and sports equipment (fully covered)
- Category 8 – Medical devices (fully covered)
- Category 9 - M&C Instrument (fully covered)
- Category 10 - Automatic Dispensers (fully covered)

2.2.7.3. Legal elements

As other Spanish WEEE collective take-back systems, the legal background is the Spanish Royal Decree 208/2005 of 25 February on electric and electronic equipment and its appropriate waste management (transposition of European Directives 2002/96/EC and 2002/95/EC)[3].

[3] *Information source: Weeeforum - European Association of Electrical and Electronic Waste Take-Back Systems*

2.2.8. Ecoasimelec Foundation [Example 7]

2.2.8.1. Organizational and legal elements

ECOASIMELEC (not-for-profit organization) is Asimelec's Foundation aimed at the development, implementation and management of an integrated waste management scheme for WEEE, in agreement with European, Spanish regulations currently in force, mainly, Spanish Royal Decree 208/2005 of 25 February on electric and electronic equipment and its appropriate waste management. This foundation was constituted in 2005. ECOASIMELEC has been created in order to cover any sector and company falling within one or more categories under WEEE Directive (categories 1, 2, 3, 4, 6, 7, 8, 9 and 10) and not included in one of the other two foundations promoted by Asimelec (TRAGAMÓVIL and ECOFIMÁTICA, both explained below). ECOASIMELEC has already more than 450 members, representing sectors such as computing, photography, medical equipment, slot machines, monitoring and control or telecommunication and radio communication.

2.2.8.2. Logistical and technological elements

This scheme is entirely financed by producers. They pay an initial contribution to enter the scheme and then the quarterly financial contribution of each producer is calculated on the basis of products placed in the market.

ECOASIMELEC manages WEEE streams from both household and professional origin. The Foundation has a network of temporal storage points and agreements with several recycling companies over Spain.

Finally, it collaborates with other integrated waste management and public administrations in doing campaigns to raise public awareness about the importance of selective collection of end of life electrical and electronic devices.

2.2.9. Ecofimática Foundation [Example 8]

2.2.9.1. Organizational and legal elements

ECOFIMÁTICA (not-for-profit organization) is other Asimelec's Foundation aimed at the development, implementation and management of an integrated waste management scheme for office equipment (printers, copying devices, faxes or electric and electronic typewriters) that are included in the Category 3 of Spanish Royal Decree 208/2005 on electric and electronic equipment and its appropriate waste management.

ECOFIMÁTICA allows to producers and distributors of this type of electrical and electronic devices to fulfil the current legislation related to waste management. This initiative has been promoted by various groups shown in figure 6:

Fig. 6: ECOFIMÁTICA initiative

2.2.10. Ecopilas Foundation [Example 9]

2.2.10.1. Organizational elements

ECOPILAS Foundation was born in 2000 for the environmental friendly management of used batteries. ECOPILAS is a collective take back system in Spain for this type of waste. The companies' founders represent 70% of the Spanish sector. The Foundation board is composed by: Energizer, Cegasa, Philips, Sony, Kodak, Anged and Asimelec.

The main objectives of ECOPILAS are as follows:

- To implement a selective collection and recycling system for used batteries.
- To respond to the co-responsibility principle of producers and retailers in waste management.
- To facilitate the joining to the integrated waste management to the producers.
- To reduce the environmental impact of used batteries.
- To urge producers to reduce the content on possible hazardous substances in batteries.
- To keep in contact with other European batteries collective take back systems.
- To collaborate with public administrations.

2.2.10.2. Legal elements

The legal background is the Spanish Royal Decree 106/2008, February 1st on batteries and accumulator and their appropriate waste management. According to this legislation, the stakeholders have some obligations. The most important ones are listed below:

- Producers: collection and end-of-life treatment of the used batteries, to finance the integrated waste management, to guarantee the performance of collection and recovery targets and to mark correctly their batteries.
- Distributor: to accept used batteries without charge for consumers, to facilitate the collective take back system financing asking a separated statement in invoices of the contribution charge to the collective system, to inform the consumers that batteries prices include the recycling cost and to inform consumers about the possibility of giving the old batteries in the shop.

2.2.10.3. Logistical and technological elements

ECOPILAS has different collection points distributed in the whole Spanish territory. These points are located at clean points, schools, public centres and shops.

The ECOPILAS logistic system takes into account used batteries from household and professional origin and establishes specific logistic models for each case:

- Household waste: periodic collections in clean points, municipal containers and containers in stores and shops.
- Professional waste: collections of a minimum amount of used batteries on demand. Also according to routes with defined frequency.

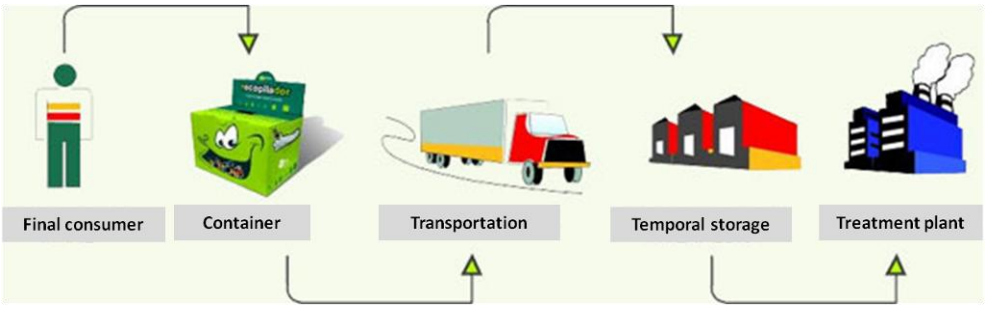

Fig. 7: Logistic scheme (ECOPILAS)

2.2.11. Tragamóvil Foundation [Example 10]

2.2.11.1. Organizational and legal elements

TRAGAMÓVIL (not-for-profit organization) is other Asimelec's Foundation aimed at the development, implementation and management of an integrated waste management scheme for telecommunications equipment waste and accessories (especially, mobile phones) that are included in the Category 3 of Spanish Royal Decree 208/2005 on electric and electronic equipment and its appropriate waste management. TRAGAMÓVIL was founded in 2003 and it is promoted by Telefónica, Motorola, Sony Ericsson, Nokia, Panasonic, Orange, Vodafone and NEC.

2.2.11.2. Logistical and technological elements

TRAGAMÓVIL Foundation has collection points of mobile phones and their accessories distributed in all regions of Spain: telephony shops, technical service, clean points, town halls, universities, storages and commercial centres.

2.2.12. Ecotic Foundation [Example 11]

2.2.12.1. Organizational elements

The ECOTIC Foundation is a non-profit private organization, whose establishment has been promoted by the main Consumer Electronics companies. Founded in 2005, ECOTIC works towards environmental protection and sustainable development through the awareness and training of manufacturers, distributors and users of electrical and electronic devices.

To comply with the obligations established by the Spanish and European legislation (mentioned above), a number of manufacturers, importers and distributors of electrical and electronic devices have joined together in ECOTIC Foundation, an organism that manages the WEEE of its affiliated enterprises through its Integrated Management System. Its mission is not only to conveniently recycle the wastes that are generated by its affiliates after the use of these devices, but also to do it in the most efficient and economically feasible way, so that the system is environmentally and economically sustainable to guarantee its durability. The manufacturer's liabilities which are assumed by ECOTIC are administrative procedures, information to the Industrial Establishment Register under the Ministry of Industry, Tourism and Trade of the amount of electrical and electronic devices placed in the market and WEEE management.

The ECOTIC Foundation's main goal is environmental protection and sustainable development. For the achievement of this objective, the Foundation works in the following activities:

- Establishment, development and management of waste collection, treatment and control systems of electronic and telecommunications devices, equipment and components at the end of their lifespan.
- Realization of studies and investigations about WEEE collection, treatment and control.
- Release to all society of information about the collection, treatment and control of this type of waste.

- Development of scientific and technological activities of debate and training about WEEE and its management.
- Transmitting the philosophy of sustainable development in the field of electrical and electronic equipment and devices.
- Transmitting the philosophy of sustainable development in the field of electrical and electronic equipment and devices.

2.2.12.2. Logistical elements

The categories of electrical and electronic equipment covered by ECOTIC are:

- Category 1 - Large Household Appliances
- Category 2 - Small Household Appliances
- Category 3 - IT and telecommunications equipment
- Category 4 - Consumer equipment
- Category 5 - Lighting equipment
- Category 6 - Electrical & Electronic Tools
- Category 7 - Toys, leisure and sports equipment
- Category 8 - Medical devices
- Category 9 - M&C Instrument
- Category 10 - Automatic Dispensers

ECOTIC is currently composed of six Activity Sectors:

1. Consumer Electronics (cat. 3 and 4).
2. Air Conditioning (cat. 1).
3. Professional Electronics and Electromedicine (cat. 3, 8, 9 and 10).
4. Toys (cat. 7).
5. Lighting equipment (cat. 5).
6. Other activity sectors (cat. 1, 2, and 6).

Each Activity Sector functions independently, has a similar structure with its own Board, and works with its own budget approved by the Board. Each Sector administers and controls its costs and expenses, which must be approved by the Foundation's Board. Each Activity Sector's budget comes from corporate members, the results of market participation and from the manufacturer's responsibility. All the Activity Sectors provide the Foundation with its budget.

Each Activity Sector, in general, carries out the following activities:

- Organization: organize the sector's activity through the internal organization regulation.
- Recycling: localize and contract recycling capacity in Spain or abroad (if necessary), according to price and service competitiveness; negotiate services.
- Logistics: according to recyclers and communities, depending on whether they offer this service; negotiate the service; subcontract.
- Market Control: data; companies that are not members of the Activity Sector, relations with other Activity Sectors; relations with other platforms; relations with other countries, entities or recyclers.
- Carrying out trial tests and research projects: as a complement, the Activity Sectors promote

ECOTIC WEEE recycling cycle

End users of electrical and electronic devices should be able to dispose of this waste free of charge. The manufacturers of WEEE should manage and finance the recycling cycle of the devices

from collection at recycling points, transportation and treatment to the adequate elimination of all waste.

WEEE collection is based on three fundamental points of collection and storage, which are:

- Clean Points and other municipal points, where users can hand over their WEEE.
- The distribution companies' own storage.
- ECOTIC's Freight Grouping Centers (FGC), which receive Clean Point and distributor WEEE before they are transported to recycling companies.

From the collection points, WEEE is transported by the logistics operator to the recycling companies.

Fig. 8: WEEE recycling cycle (ECOTIC)

2.2.12.3. Technological elements

In general, there are four methods to recycle and recovery WEEE:

- Manual dismantling and separation of the device's components
- Mechanical recycling: removal and crushing of materials
- Incineration and refining, to recover metals
- Chemical recycling, of precious metals (gold, silver) from printed circuit boards.

Current recycling technologies differ depending on the type of device and its main components. In the WEEE end-of-life treatment several material streams can be obtain:

- Metals: the first separation established is between ferrous (iron, steel) and non-ferrous (aluminium, copper, precious metals) metals. Ferrous metal separation through magnetization is simple. Metals can be recovered through crushing, incineration or cooling. Some chemical processes allow precious metals, such as gold or silver, to be separated from the printed circuit boards.
- Glass: identification and separation of products with glass elements is complicated because these materials contain heavy metals, particularly television sets and monitors. The cathode ray tube is divided into glass from the screen (composed of barium and strontium) and conical glass from the funnel (with high lead content). To separate and recycle this glass, mechanical and thermal methods are used in conjunction with chemical methods to recover metal dust.
- Plastics: the difficulty encountered when recycling plastic is correctly classifying the various polymers. Most of the recyclers use manual separation, although they are starting to implement common polymers identification through automatic technologies. Other mechanical systems include classification through air, sink-float or electrostatic separation.

The content of materials varies significantly according to the type of electrical and electronic devices. The table below list the percentages of several materials for some device categories.

Table 4. Average material content according to device category (Ecotic)

Device Category	Ferrous Metal	Non-ferrous Metal	Glass	Plastic	Others
Major Appliances	61%	7%	3%	9%	21%
Small Appliances	19%	1%	0%	48%	32%
IT Equipment	43%	0%	4%	30%	20%
IT Equipment	13%	7%	0%	74%	6%
Television sets, radios, etc.	11%	2%	35%	31%	22%
Gas Lamps	2%	2%	89%	3%	3%

2.2.13. European Recycling Platform España – ERP España [Example 12]

2.2.13.1. Legal elements

European Recycling Platform (ERP) arises as an integrated management system for WEEE in December 2002 upon the initiative of four great companies: Braun, Electrolux, Hewlett Packard and Sony in response to the European Directive 2002/96/CE on Waste Electric and Electronic Equipment. In Spain, ERP was implemented in 2005 when the Directive was transposed into the Royal Decree 2008/2005 of February 25th on electric and electronic equipment and its appropriate waste management.

In 2008 the Royal Decree 106/2008 on batteries and accumulators and its appropriate waste management is published. Given the existing synergies between this type of waste and WEEE and, with the objective of being able to offer a complete service to its customers, ERP decides to establish itself as a collective take-back system of batteries and accumulators as well: button batteries, standard batteries, portable accumulators, batteries and accumulators from automotive and industrial sectors, and others.

2.2.13.2. Organizational elements

The ERP mission is to offer its members in Spain and Europe a complete compliance with the legislation corresponding to WEEE and used batteries and also to create a recycling platform on a European level. The objectives are:

- To promote high quality environmental practices.
- To offer a competitive cost/service relationship.
- To offer personal service to the companies collaborating in the recycling process: associated companies, distributors and local entities.
- To offer total management tracking, from the collection to its treatment.
- To maximize the constant improvement of the processes and technologies.
- To carry out a continuous follow-up in order to guarantee competitive prices.
- To participate in campaigns of information and communication addressed to citizens and professional entities destined to instate recycling in this kind of waste.

2.2.13.3. Logistical and technological elements

The service model of ERP is based upon a collection network that, in Spain, comprises the entire national territory. ERP specializes in the collection, transportation, treatment, reutilization and recycling of waste:

- Originated at homes, through the municipal clean point network (also called eco points, green points, etc…).
- Originated at distribution.
- Originated at industrial or professional area

The basic model of ERP as an integrated management system of WEEE, in accordance with the EU directive, can be explained in the Fig. 9.

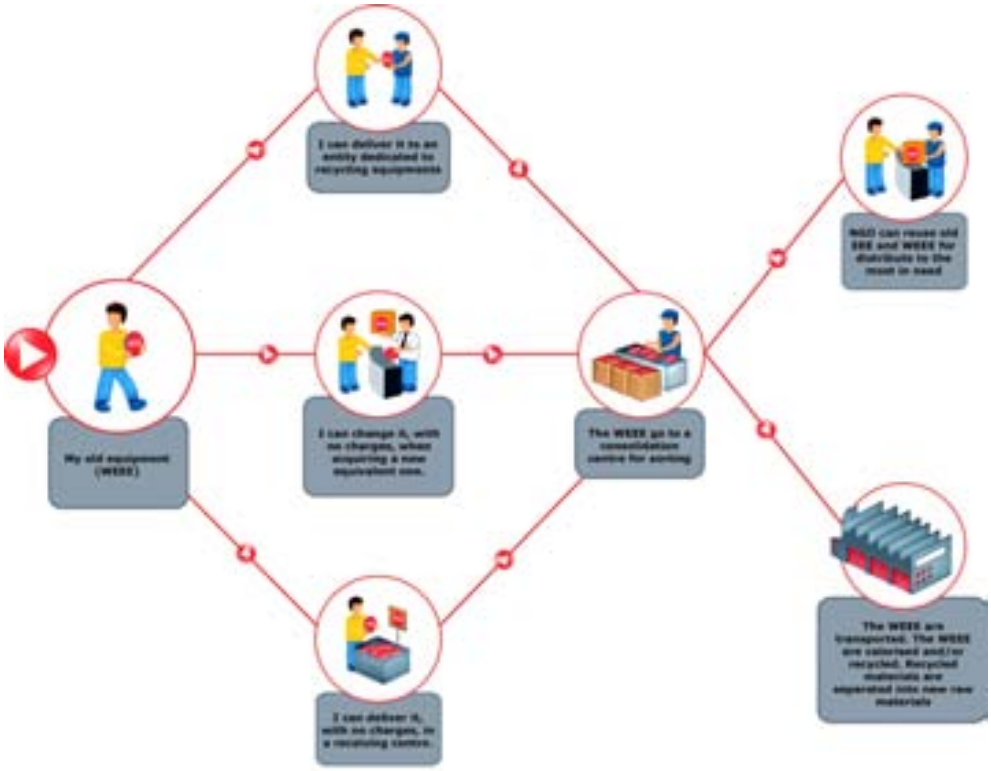

Fig. 9: ERP collection network scheme

The categories of electrical and electronic equipment covered by ERP are:

- Category 1 - Large Household Appliances
- Category 2 - Small Household Appliances
- Category 3 - IT and telecommunications equipment
- Category 4 - Consumer equipment
- Category 5 - Lighting equipment
- Category 6 - Electrical & Electronic Tools
- Category 7 – Toys, leisure and sports equipment
- Category 8 – Medical devices
- Category 9 - M&C Instrument
- Category 10 - Automatic Dispensers

2.2.14. Asociación para el Reciclaje de Lámparas – AMBILAMP (Lamps Recycling Association) [Example 13]

2.2.15. Organizational and legal elements

AMBILAMP is a not-for-profit organization founded specifically for collection and treatment of lamps waste included in the category 5 (lighting equipment) of the Spanish Royal Decree 2008/2005 of February 25th, on electric and electronic equipment and its appropriate waste management:

- Straight fluorescent lamps (excluded filaments bulbs)
- Compact fluorescent lamps
- High intensity discharge lamps, including pressure sodium and metal halide lamps
- Low pressure sodium lamps
- LEDs Retrofit

2.2.16. Logistical and technological elements

AMBILAMP is an integrated waste management whose main mission is to offer its members (lamps producers affected by the Royal Decree 208/2005) a complete compliance with the legislation. AMBILAMP has organized an integral collection and environmental friendly recycling system for the lamps waste included in the category 5 of the Royal Decree. From the collection points (municipal “clean points”, small and big shops, distributors or installers) the used lamps are shipped to the recycling plant to recover plastics, metals, glass, mercury and fluorescent powder concentrates.

Fig. 10: Special containers for end-of-life lamps

2.2.17. Ecolum Foundation [Example 14]

2.2.17.1. Organizational and legal elements

ECOLUM is other Spanish collective take-back system for collection and recycling of luminary waste included in the category 5 (lighting equipment) of the Spanish Royal Decree 2008/2005. For general details, see information about AMBILAMP, mentioned above. ECOLUM only provides its waste management services to products manufactured and/or marketed by companies’ members of the ECOLUM collective management system.

2.2.18. Sistema Integrado de Gestión de Neumáticos Usados – SIGNUS (Integrated management system for used tyres) [Example 15]

2.2.18.1. Organizational and legal elements

SIGNUS is the Spanish integrated management system for used tyres. It is not-for-profit organization created by tyres producers as an instrument to fulfil their obligations according to the Royal Decree 1619/2005 of 30 December, on end-of-life tyres management. Other legislation to take into account is:

- Spanish Law 10/1998, of 21 April, on Waste
- European Waste Framework Directive 2008/98/EC

2.2.18.2. Technological and logistical elements

In terms of composition (Table 5), tyres are blended products, made essentially from rubber and textile and/or reinforced with steel. Prior to vulcanisation of the rubber, different elements intervene to endow the blend with the appropriate performance capabilities for each use. Products used include carbon black (this is the reinforcement infill, consisting of very small carbon particles), extender oils and other chemical agents (including sulphur, zinc oxide, antioxidants and accelerants, etc).

Table 5. Approximate composition of a tyre by weight (Signus)

Material	% by weight
Rubber	41-66
Carbon black	22-25
Steel	15-25
Textile	0-6
Zinc oxide	1-2
Sulphur	1
Others	6-8

Structurally a tyre is made up of different parts, which are joined together by vulcanisation. The composition and performance of each is vastly different to the others and are conditioned not just by the overall requirements but also by the functionality of each tyre part.

SIGNUS organizes and manages the whole recovery process of used tyres: collection without charge in specific points, treatment and final applications (secondary raw material and waste derived fuel in cement plants) for fractions recovered from treated tyres. Other alternative for some used tyres is to extend the life span by means of reconditioning or re-grooving. This reuse process consists of changing the old tread layer for a new one. A reuse tyre only contents 25% of new raw material. The SIGNUS operational network is composed by Collection and Classification Centres and Shredding/granulation facilities.

Fig. 11: Re-grooving process

Some applications for rubber granulates from end-of-life treatment of used tyres are, as follows:

- Filling and bases of artificial grass fields
- Grounds for children parks
- Ornamental applications in gardens and rounds-about
- Soles
- Acoustic barriers

Fig. 12: Safety grounds

2.2.19. Treatment of organic waste in the metropolitan area of Cordoba / Spain [Example 16]

Organic waste is a major component of municipal solid waste in Spain, most of this waste stream is originated in households. The innovative experience of Cordoba in Andalusia (Southern Spain) achieves high rates of recycling of the organic matter via composting and selective collection at household level.

Municipal solid waste in Cordoba is managed by the public company SADECO. The management of SADECO ranges from the collection of waste deposited in the containers to the transport, treatment, recycling and disposal of waste. The objective of the company is to recycle the most possible amount of waste according to the Spanish and European legislation.

The consolidated model of collection containers in public places in Spain is based on four containers: i) glass, ii) paper and cardboard packaging iii) plastic, metal and multilayer and iv) residual fraction, which includes material organic. However, the metropolitan area of Córdoba (hereinafter Cordoba) goes further in the separation at source since organic matter is collected selectively. This procedure facilitates the use of organic material for composting and allows recycling of about 50% of the total waste generated, which is the estimated proportion of this waste. These results are higher than in other provinces in the region, for instance in the province of Malaga, only 5.11% of the solid waste collected could be composted in 2009 (Observatorio Provincial de Sostenibilidad, Málaga).

Organic matter with other components is very difficult to completely separate in composting plants, resulting in a product with contaminants that could reach agricultural land or issued in biogas plants. Separation at source, at household level, is therefore essential.

The experience of Cordoba can be extended to other populations. The high organic content in the municipal waste stream of Western African countries is ideal for composting, but there is not enough accurate, unbiased information available to municipal managers, who may be familiar with composting in agriculture, but do not see it as a way to solve their urban waste problems. The potential for replication lies on the many benefits of the composting process:

- It provides a useful way of reclaiming nutrients from organic refuse
- Saves valuable landfill space and possible contamination of land and water due to landfill leachate
- Can be used as fertiliser on farmland or in the garden
- Improves the condition of soils

2.2.20. Logistical elements

2.2.20.1. Collection of waste

In 1993, SADECO introduced in Cordoba the selective collection at source of the organic fraction (into grey container), and the collection of the inert fraction jointly with packaging material (into yellow container). This selective collection allows that the organic fraction could be transformed into high quality compost, which is free of any type of contaminant, thus this recycling output is perfect to use in soil remediation.

Furthermore the system maintains the selective collection of other types of waste: glass into green container and paper into blue container. There are also independents systems of collection of damaging materials for the compost production (batteries, phytosanitary waste, etc.); at the same time different areas were created for voluntary disposal of especial and recycling materials which are called "*Ecoparques*" (Eco-parks).

The reasons which justify the adoption of this collection system for the organic matter are described below:

- The organic matter represents the half weight of the garbage bag. Therefore, any recycling action must affect the recuperation of this major fraction.
- The organic fraction is the more problematic component in the treatment of urban solid waste: smells, gases and liquid waste. The improvement of an urban solid treatment system depends on this fraction.
- Waste recycling cannot mean moving harmful substances from landfills to recycling products. The current legal framework fixes the maximum levels of contaminating substances in compost. Likewise, the organic fraction is the main problem for the separation and recovery of inert fraction (mainly packaging).

2.2.20.2. Transportation of waste

The transport of urban solid waste is carried out by a fleet of trucks specialized in each type of waste, in the same way containers are also specific to each type of waste.

The use for the urban solid waste managed by SADECO could be the recycling, the composting and the landfill of rejection materials. On the other hand, the carcasses are burned in a special crematory, according to the current regulation.

2.2.21. Technological elements

2.2.21.1. Technologies for treatment

All residues collected in the city are treated in the “Complejo Medioambiental de Córdoba” (CMC). The main installations for the treatment of organic waste are described below:

The composting and urban residues recycling plant treats separately residues from waste sorting. There is a line where organic waste is treated and another line for the inert fraction and packaging materials. In the line of organic fraction selection and line of refinement the organic matter is treated including bio solids. Once the organic fraction is separated in a trommel, it is mixed with rests of pruning and transported to the composting plant where after maturing and fermentation phases it is transformed into a high quality organic fertilizer free of contaminants. Likewise, bio solids are mixed with pruning residues and introduced to the composting system. Finally, the composting plant has a refinement unit to produce the final compost ready for market.

Technologies for recovery/recycling:

The recycling/composting plant treats residues from waste sorting at source. This plant treats on the one hand the organic residues selectively collected in the grey containers, and on the other hand packaging and inert waste collected in the yellow containers.

The composting plant process has the following steps:

- Control and reception
- Supply
- First triage
- Breaking of bags and granulometric sorting
- Magnetic sorting and secondary triage of inorganic matter
- Package of cardboard and plastic
- Package of iron and non ferrous scrap
- Magnetic sorting
- Fermentation
- Compost granulometric sorting
- Compost densimetric sorting
- Maturation
- Pilot Plant of recycling and composting

2.2.21.2. Technologies for disposal

The “Complejo Medioambiental de Córdoba” (CMC) has a controlled landfill of high density without cover and aerobic fermentation. The landfill is functioning since 2001 and it receives the residues rejected in the composting plant as well as other residues which are not recyclable.

Regularly (two or three times a week) the accumulated material is moved by bulldozers, being impermeable clays and similar materials firstly poured. Inert waste generated in the city of Cordoba, such as soil, rubble, or construction and demolition waste are treated in a specific plant. Inert waste is deposited in the quarries; subsequently they are buried jointly with soil, thereby recovering the landscape altered by previous mining activity.

2.2.22. Legal elements

Waste management in the city of Cordoba is governed by the Spanish law 10/1998 about waste management, jointly with the Spanish Royal Decree 1981/2001, which regulates the disposal of

waste in landfills. This legal framework has been updated in the last years including mandatory rules form European directives regarding treatment and management of urban solid waste, and shows the tendency to minimize the amount of waste and increase recycling; that is the same objective that SADECO`s policy pursues in its management activities.

The last European directive, 2008/98/CE, lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use. With this purpose, the countries of the European Union must define national systems of waste management in which the disposal is the last option (following the waste management hierarchy), and the promotion of recovering and recycling will be more important than before this directive. With regards to the organic fraction; the European directive establishes its selective collection, specific treatment and the way to be used for compost production.

Spanish government has approved the “Integral National Wastes Programme” (PNIR) for the period 2008-2015; which has been financed by the Ministry of Environment. This Programme is based on “Reduce, Recovering and Recycling”, and tries to achieve the following objectives:

- Halt the increase of waste generation that exists actually.
- Eliminate the illegal landfills.
- Reduce the disposal and to promote the prevention, the recovering and the recycling of the most fraction of waste.
- Build new structures involved in management of waste, and improve the old ones.
- Avoid waste contributes to climate change.

2.2.23. Organizational elements

SADECO is the Municipal Solid Waste Company in Cordoba and was founded by the Cordoba City Council in 1986. SADECO is a public company whose main function is the management and control of the urban environment. SADECO`s responsibilities comprise the selective collection at source, transport and final treatment of waste, and recycling of the different fractions of waste. Services and activities of SADECO are financed by Cordoba City Council.

The organization of the company is based on the service that it provides:

- Recollection of urban waste
- Treatment and final disposal of the waste
- Recycling and compost production
- Streets, schools and public buildings cleaning
- Technical and maintenance services
- Education and support services

Citizen collaboration and raise awareness:

Cordoba waste management is accompanied by strong campaigns to increase public awareness. These campaigns have two stages: the first one focused on general information and the second one focused on maintaining appropriate habits to achieve sustainable good practices. The objective is to attain a high quality selective separation at source with the collaboration at household level of population responsible of waste sorting in their garbage bins.

In order to extend the benefits of recycling to the highest amount of inhabitants, an agreement between the City Council and the Federation of Neighborhood Associations was signed. This agreement included the distribution of 115,000 garbage bins for selective collection among the households of the city. Likewise, SADECO has an education service working in raise awareness activities at schools in collaboration with teachers and children parents.

Furthermore, user-guidelines have been developed to describe how to use the different bins and the benefits of recycling. The guidelines were distributed jointly with the garbage bins.

Example of the organic fraction instructions bin included in the guidelines:

→ *How to use the organic garbage bins?*

- Deposit the garbage in closed bags with no liquid inside. Do not throw ashes or other materials that may damage the container (such as furniture, home appliances, etc.)
- Always leave the lid closed to avoid bad smells
- The garbage should always be placed inside the container, never out on the floor
- Observe hours of deposit, according to the rules governing the collection in your area

→ *What to deposit into the bins?*

- Leftovers, rests of pruning or sweeping
- Remember that the organic matter deposited in this container will be recycled and turned into COMPOST. For this reason, we should not ever deposit glass, paper, cardboard, plastics, metal, cartons, batteries and textiles. Everything has its place

Fig. 13: Compost SADECO

This selective collection of organic waste started with a population of 25,000 inhabitants involved in waste sorting at source. This amount has been being increased in the last years and the objective is to extend the experience to the whole population of Cordoba.

During 2009, the Compost produced has been successfully marketed, used in Research and Development activities by universities and research centres, freely distributed to the Botanical Garden, schools, neighbourhood associations, etc. The production of compost in the city of Cordoba is estimated at 25,000,000 kg/year.

2.3. Examples from Germany

2.3.1. Local collection system for household waste [Example 1]

2.3.1.1. Legal and Organisational elements

In Germany the local municipalities or counties are responsible, by law, for the collection and disposal of waste (Art. 15 Para 1 of the Waste Recycling and Disposal Act, Art. 4 Para 1 of the waste law of Hessen, Art. 5 Para 1 of the waste law of North-Rhine Westphalia). Therefore the local authorities have the right (and an obligation) to set up waste charge regulations.

The technical side of waste management is carried out by special associations for the waste disposal ("Abfallzweckverband"). The waste disposal association are legal entities made up of several municipalities with the aim to collect and transport residual waste, organic waste and waste paper as well as to recycle and dispose waste. The establishment of such an association or the conversion of the structure of an existing association is advisable for economic and logistic reasons.

The municipalities raise disposal fees from their citizens for the disposal of waste. These fees are required to cover the costs of the disposal. A realization of profits is not intended by the collection of those waste fees (the principle is that of cost-recovery in accordance with the law on charges). The levels of waste fees vary considerably across Germany. It is obligatory for the citizens to use the smallest possible bin. According to German jurisprudence, citizens are obliged to dispose of their waste using the local waste disposal system. The reason for this in case law is the fact that the fees for the public disposal service have to be paid by the community.

In several waste laws of the German Länder, it is stated explicitly that waste charges for the disposal of waste shall constitute incentives to prevent waste as well as incentives to separate and recycle waste (e.g. Art. 9 para 2 of the waste law of North Rhine-Westphalia). In other states of Germany (Länder) these incentives are not regulated explicitly (e.g. the waste law of Hessen) but their regulations have to consider the principle of waste avoidance in a similar way.

The calculation of waste charges in Germany basically follows two models:

- Calculation according to the number of persons per household (flat-rate model, applied by the majority of the municipalities in Germany). Waste fees are usually divided into an annual fee and a container fee. The annual fee depends on the number of persons in the households; the container fee depends on the size of the container, usually a wheeled bin.
- Calculation according to the quantity of the waste disposed (pay-per-volume model; e.g. municipalities in the counties "Darmstadt-Dieburg" and "Gießen" in the State Hessen).

The disadvantage of the flat rate per-person charging system is that there are no "strong" incentives to avoid waste, because for the calculation of charges the quantity of disposed waste is not important, only the number of persons matter. With the introduction of the pay-per-volume system, waste avoidance and separation could be promoted by financial incentives and in this way the competent local authority will save costs where residual waste treatments are relatively expensive. The decision to introduce the pay-per-volume model ("waste producer pays") thus follows both, the cost recovery principle and the goal of waste avoidance.

2.3.1.2. Logistical elements

To realize a variable charging for the residual waste, two models are used in Germany:

- Bar Code System and
- Token system ("Wertmarkensystem")

Citizens can choose between different sizes of wheelie bins (50 l - 240 l, sizes vary from county to county) and between two different disposal frequencies (twice a month or once a month).

Example: Structure of the Waste Disposal Charge in the County Gießen

Standard Volume

In order to determine the correct wheelie bin size for a household, there is usually set a need of 15 litres residual waste per person and week (standard volume).

Minimum Volume

If the waste will be separated exactly, citizens get along even with a minimum volume of 7,5 litres per person and week. We have seen that at least this minimum volume fee has to be paid by everyone.

The structure of charges is shown below. Other household wastes, like the DSD-waste ("Gelber Sack"), organic waste ("Braune Tonne") and waste paper are not directly included in the above mentioned system, but the cost decreasing effects of those waste streams are taken into account in the overall-calculation of waste charges.

Residual waste

Size of the bin	Emptying intervals	Fee
60 Litre	once a month twice a month	71,40 Euro 147,60 Euro
120 Litre	once a month twice a month	133,20 Euro 277,20 Euro
240 Litre	once a month twice a month	262,80 Euro 538,80 Euro
1.100 Litre-bin	once a month twice a month	1.212,00 Euro 2.472,00 Euro

Organic waste

Size of the bin	Emptying interval	Fee
120 Litre	twice a month	28,80 Euro
240 Litre	twice a month	57,60 Euro

Waste Paper

240-Liter-waste paper bins are placed at the disposal of all private households free of charge (in addition to their ordered wheelie bins of residual waste). The waste paper bin is emptied monthly.

Neighbour wheelie bin

One-person-households can reduce the costs using a wheelie bin with neighbours together. The neighbours only have to agree on who is paying the fee; only this person receives then the fee-invoice.

For the local competent authorities the shift to a pay-per-volume system has a - partially considerable - cost saving factor as a consequence. For example after changing to the pay-per-volume system the county Gießen has saved costs at a value of 1,3 millions Euro per year. The investment costs, which require a district or county far conversion of the waste charge system, can be gained by saving with the quantities of waste.[4]

2.3.2. Municipal collection and dismantling centres for WEEE [Example 2]

According to the German Law on WEEE[5] e-waste has to be collected separately from other (mixed) municipal solid waste to promote reuse and recycling and to minimise the pollution of the main waste streams by hazardous substances. The responsible public waste disposal authorities are in charge to offer the private households in Germany a suitable collection infrastructure for e-waste in compliance with the European and the German WEEE. That means the service of e-waste collection has to be free of costs for the private households and has to be structured on the regional and local level to avoid – for instance – large distances for the residents to the next collection point for e-waste. Kerbside and bring systems are both in place to collect the e-waste from private households. Nevertheless the collection of the e-waste by responsible public waste disposal authorities (cities and counties) has to fulfil the obligations of the WEEE, which means the collection has to be carried out in such a way that the reuse and recycling of e-waste is not hampered.

In many German cities and counties municipal collection and dismantling centres for WEEE have been established to fulfil the objectives and obligations of the WEEE. Very often the communities have decided to choose a model which combines the requirements of the WEEE for environmental protection with social issues. Therefore former jobless people, people with inadequate qualifications for the “first” labour market and disabled people are very often employed in the municipal collection and dismantling centres for WEEE. A good example is the AZUR GmbH (www.azurgmbh.de) which is commissioned by the county of Darmstadt-Dieburg (sub-urban area with about 280,000 inhabitants).

The AZUR GmbH offers the full service for collection according to the German WEEE via kerbside and bring systems. Private households could arrange dates for the collection at home by using a telephone hotline. Several sub-stations in different villages of the county as well as the collection and dismantling centre itself are open for private households to deliver their e-waste. Special conditions are also in place for commercial customers. Every household in the county has got an actualized waste collection plan which informs about all the waste management services within the county including the collection points for e-waste and the opening hours respectively.

The experiences of this system after several years in practice could be stated as very positive. The citizens appreciate the flexible service for e-waste collection (kerbside and bring system) and the good information policy. Furthermore the collection centre is developed now to a real dismantling and reuse-centre. With support and supervision by experienced technical experts the employees of the centre have improved their skills concerning dismantling as well as repair activities for electric and electronic devices (TVs, washing machines etc.). Meanwhile the collection and recycling centre is a well-known regional address which offers repaired second-hand ware for fair prices which is an overall important financial factor for the municipal collection and recycling centre. The positive social effects are also evident.

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[4] See www.uni-giessen.de/ilr/gaeth/projekte/pro_gebuehrensystem/pro_gebuehrensystem.html; the introduction of the flexible pay per volume system in the county Gießen was scientifically attended by a university project at the University Gießen.

[5] Elektro- und Elektronikgerätegesetz; 16 March 2005 (BGBl. I S. 762)

The details of the system could not one-to-one exported to West Africa due to different settlement patterns, infrastructures etc. Nevertheless the core elements of the municipal collection and recycling centres for e-waste could be adapted for countries in West Africa, too. First the installation and enforcement of nationwide laws concerning e-waste including the principals of separate collection, re-use, recycling and environmental sound disposal. Second a clear – and nationwide consistent – responsibility of the regional local authorities for the collection system. Third the enhancement of the acceptance for the municipal collection and recycling centres by the realization of additional social benefits as described beside a better resource efficiency and protection of the environment.

2.3.3. Maintenance of landfill sites [Example 3]

In recent years, several European countries (e.g. Germany, the Netherlands or Switzerland), have banned the disposal of untreated waste in landfills. In these countries, only the ashes from incineration or pre-treated waste may still be deposited.

Since 2005 wastes in Germany can no longer be landfilled without pretreatment (according to the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements – "Abfallablagerungsverordnung"; now integrated by the Landfill Ordinance – "Deponieverordnung"). Prior to storage, waste must be treated in such a way that it cannot degrade further or release pollutants. In future, recoverable substances will be separated in state-of-the-art installations and the energy from the wastes will be utilized. Only a small non-recoverable part of maximum 30% will still have to be stored in well-equipped landfills.

2.3.3.1. Legal Elements

In Germany the "Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal" regulates the requirements for waste disposal in consideration of the public interest.

According to these statutory provisions the waste that is not recovered shall be permanently excluded from closed substance cycle waste management, and it shall be disposed of permanently in a manner in keeping with the public interest. Waste shall be disposed of in such a manner that the public interest is not impaired. Impairment occurs when, in particular,

- human health is impaired,
- animals and plants are endangered,
- water bodies and soil are harmfully influenced,
- harmful influences on the environment are caused by air pollution or noise,
- the aims, principles and other requirements of regional planning, and the interests of nature
- conservation, landscape management and urban development, are not considered adequately or
- The public's safety and the public order are otherwise threatened or disturbed.

In the "Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal" will be regulated that the preparation of re-use and recycling of municipal waste shall constitute at least 65 per cent by weight at the latest starting from 2020.

The provisions of the above mentioned Act will be concretized by the recently amended Landfill Ordinance. The Ordinance now integrates the requirements of the suspended "Ordinance on Environmentally Compatible Storage of Waste from Human Settlements" as well as the requirements of the suspended "Ordinance pertaining to the recovery of waste at surface landfills".

With the Landfill Ordinance the Environment Ministry has established standards for the recovery of waste which are similarly strict to those for disposal. Since then all waste has to be regularly pretreated prior to a disposal on landfills. In the future this will prevent the false declaration which is

criticized by many waste treatment facility operators. Landfill operators who comply with their legal obligations and fill and close down their landfills according to the best available technology shall not suffer economic disadvantages because of waste tourism. This is why strict provisions have been established especially for using waste to shape the surface of a landfill body (profiling), where big volumes of wastes are recovered. Therefore, waste may only be used for profiling if all other possibilities to minimize the volume necessary for this purpose have been exhausted.

The Ordinance will continue to regulate the pretreatment of waste. Regarding the requirements for the landfill site construction the regulation is more flexible. This means that as far as harmonised technical specifications of the kind provided for in European Law are available for construction products in liner systems and their performance characteristics make full allowance for the state of the art provided for with regard to their intended use, in particular their durability, the certification by the German Federal Institute for Materials Research shall not be required.

Landfill sites or sections of landfill sites shall be constructed in such a way that the requirements according to the regulation of the Landfill Ordinance with regard to their location (suitability of the location), the geological barrier (substrate of a landfill site) and the base liner system (requirements with regard to the state of the art, special requirements with regard to the geological barrier and the base liner system, special requirements with regard to the surface sealing system, certification of geoplastics, polymers and leak detection systems) are satisfied.

2.3.3.2. Technological elements

Just 20 years ago a great deal of domestic and commercial wastes ended up untreated on the rubbish tip. First residents complained about the stench and pollutants such as dioxins were found in the groundwater and drinking water. The digester gas methane emitted from landfills causes 21 times more damage to the climate than carbon dioxide (CO2). Domestic waste landfills became contaminated sites which result in costs for rehabilitation and after-care amounting to billions.[6]

The alternatives to landfills are waste reduction and recycling strategies. Secondary to not creating waste, there are various alternatives to landfills. In the last 15-20 years, alternative methods of waste disposal to landfill and incineration (e.g. anaerobic digestion, composting and mechanical biological treatment) have gained acceptance and were established by regulation.

Following recent findings from research and practical experience, the Landfill Ordinance added supplementary landfill classification criteria and emplacement rules that open the way for the mechanical-biological treatment of residual waste. As well as requiring that biogenic constituents be largely biodegraded, these involve separating off high calorific value constituents such as plastics, wood, paper and cardboard (40-50% average content). These high calorific value constituents are to be used for energy in high-efficiency power stations and industrial co-combustion plants, instead of being buried in landfills as they were in the past. Finally, landfills that did not comply with the Ordinance had to be closed by 2009 at the latest.

2.3.3.3. Lessons learnt

As we have seen for other European countries the process to reduce landfilling of waste and to increase the recycling and energy recovery takes a lot of time and needs first of all legal and technological framework. Nevertheless this is a very relevant issue for the West African countries. It is not the goal to reach (already) the European standards but to start with measures.

[6] Cf: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety: http://www.bmu.de/english/press_releases/archive/doc/36349.php.

2.4. Examples from Sweden (Denmark, Finland)

2.4.1. Historical development

The environmental legislation was initiated in Scandinavia during the 1970ies and had a great impact on waste management in the countries. At this time most of the waste was landfilled and with an increasing population and higher consumption rates, more and more waste was produced. Scandinavia faced similar issues as West Africa is facing today. The Swedish environmental legislation stated that the amount of landfills should decrease and focus should be on recycling. A solution was to supply the cities with energy via incineration of the waste. District heating had already been introduced, as early as in the 1940ies and distribution of energy from waste was therefore fairly easy to implement. The municipalities were responsible for waste management. A few years later the municipalities were allowed to charge waste owners for the costs of managing the waste they supplied. An infrastructure of separate collection and recycling started to form in Sweden. Waste was now being transported longer distances than before. Since the 1970ies the environmental laws have developed and more emphasis was put on recycling and producer responsibility. Today, the national waste management plan in Scandinavia follows the EU framework directive based on the principle of waste hierarchy: prevention, reuse, recycle recovery and disposal. Today, 96% of the waste in Sweden is recycled and the amount of landfills is still decreasing (Minska avfallet 2011). Waste should only be landfilled if the waste cannot be treated in any other way and is charged by a landfill tax (RVF 2005a).

2.4.2. Organisational and legal elements

The responsibility of waste management in Sweden is shared among the Swedish environmental protection agency (EPA), the municipalities and several organisational cooperatives by the packaging industry. The Swedish EPA designs the national waste management plan based on the national environmental quality objects, included here are the EU directives. Based on the national waste management plan every municipality have a local waste management plan, including all types of waste from household waste (main focus is on household waste) to industrial waste. The plan does not include recyclable material, which goes under the law of producer responsibility (see section on Packaging below). Each municipality is responsible for the collection and treatment of household waste, except waste covered by the producer responsibility law, which is the responsibility of the producers. The responsibilities of the waste owners/producers (household and industrial operators) involves sorting the waste and dispose of it in a correct way. Lastly the environmental court and the environmental court of appeal decide for permission of large scale operations that deals with environmental hazardous operations, matters relating to municipal waste disposal, and claims for damages and compensation (Naturvårdsverket 2011).

The decentralised organisation where about 300 municipalities are responsible for waste management is strengthened by its stakeholder and trade organisation Avfall Sverige – Swedish Waste Management. Their main activities are to monitor development and safeguard member's interests, to exchange experience, to work with development and investigations and to educate and disseminate knowledge. They are an important link between municipalities, and between waste researchers and practitioners.

2.4.3. Logistical elements – Waste collection

Since different actors are responsible for the waste, a large amount of the waste is sorted at the source and a great responsibility lies with the waste owner. As a private person you sort your waste in your home, combustible and biodegradable waste, and in some cases recyclables, are collected at your house. Recyclable packages are taken to recycling stations and larger waste taken to a recycling centre. This is explained below.

Household waste

The municipalities offer curb side collection of household waste and biodegradable waste. The pick-up frequency differs in different municipalities, usually once a week or once every other week. About 53 percent of the municipalities provide separate collection of the biodegradable waste from the household waste. The biodegradable waste is either composted or used as biogas (see section xx). Household sorting has been implemented due to regulating laws and information campaigns.

Fees cover the waste management service offered by the municipalities. The fee covers basic expenses such as administrative work, collection, transportation and treatment of household waste and also recycling centres, waste bins and the handling of environmentally hazardous waste from households. Every household has to pay for waste management and it is forbidden to transport waste outside the boundary of the household. The exception is if the waste can be recycled and is taken to a recycling station (Avfall Sverige 2007). In multi-family housing there are communal waste collection bins for each building block. The waste fee is normally included in the rent.

Fig. 14: Left: Household waste bins. Green bins for combustible waste and brown for biodegradable waste. Right: Collection bins outside a multi-family house. (Private)

Billing can be based on either volume or weight, with volume-based billing being far most common. The property owner chooses collection frequency and size of the waste bin and pay accordingly (Dahlén et al 2009a). Hence, the more waste taken to recycling stations, the less household waste and cheaper fee. On average, a typical Swedish single-family household paid 1940 SEK (293 USD) per year for waste collection in 2007 (Dahlén et al 2009b). Weight-based billing, where the waste truck has a built-in scale and weighs each household's waste, has been introduced in a few municipalities as a motivation to increase the amount of household waste. When introducing weight based billing the residual household, waste decreased by 50 percent. Weight-based billing could be a strong instrument to get people to sort out their waste, but waste might be thrown somewhere where it does not belong (Dahlén et al 2006).

Packaging

Since 1994 the packaging industry is, according to the polluter pays principle, responsible for packages even after disposal. The producer responsibility covers plastic, metallic and paper packaging, newsprint, tires, cars, batteries, electronics and some radioactive products. The consumers also have a responsibility and are bound to return used goods and packages to designated recycling stations and recycling centres (Förpacknings & tidningsinsamlingen 2011). In order to facilitate sorting, packages are marked stating how they should be sorted. The producers are obliged to report to the Swedish EPA.

Fig. 15: Recycling station for glass, plastic-, metal- and paper recycling (Private).

Recyclables such as newspapers, metallic, plastic and cardboard are collected by the packaging industry. Together they formed a non-profit organisation to manage the recycling, which is financed by a packaging producer fee. Recyclables are, unlike household waste, mainly collected at recycling stations, so the waste owner has to transport their recyclables there. Today there are 5800 recycling stations in Sweden, often situated close to a grocery store or other places where people often pass. The more accessible these recycling stations are the more is delivered. Unlike the municipal waste collection system, the idea of recycling stations is based on citizens' car ownership (Dahlén et al., 2009a). There is, however, a trend towards more doorstep collection of different recyclables. Some municipalities use special multiple-compartment waste trucks. One truck can then collect household waste, biodegradable waste and also the recyclables at the same time in different compartments.

Bulky waste

Bulky waste is any household waste too big to fit in the waste bin. These have to be transported to recycling centres, where disposal is often free of charge for private persons. They are often managed by the municipality and staffed. A first sorting of the waste is done at the recycling centres where different type of waste goes in to different containers. Some municipalities offer household collection of bulky waste. However, most common is for the waste owner to transport the waste to a recycling station, which is, according to a study, the best solution (Avfall Sverige 2010).

Fig. 16: Waste truck with two compartments. (Private)

Batteries

Batteries are, when disposed of in the wrong way, environmentally hazardous and recycling them in a proper way is important. It is of great importance to have collection points that are easily accessible for the waste owner. Therefore the recycling industry wants to make it accessible for the waste owner to dispose them in a proper way by having battery recycling boxes located at grocery stores, a place people visits often.

Fig. 17: Battery box placed outside from a Supermarket (Private).

Re-use shops

Centres for sale of reusable products has during the last decade become more popular in Scandinavia and encourage people to reuse, remake and redesign, anything such as furniture, clothes, wood, electronics, toys etc. Designated stores as well as websites sells used items and promote themselves as a cheaper alternative as well as a better alternative for the environment. Many municipalities have shops where they sell items disposed at recycling centres that are in good shape. This is often combined with social projects, where employment is offered to people who have difficulties finding regular jobs. There are examples of where building materials in good condition are handed to recycling stations and being taken care of and reused in the real estates of the municipality (Uppsala kommun 2011).

Industry

Industries dealing with environmental hazardous waste are also under the polluter pays principle. Sweden follows the EU-definitions and directives of hazardous waste, which is based on the polluter pays principle. The responsible for a proper handling of the waste is the operational manager. They are therefore responsible to keep the organisation updated on new laws and regulations, acquire knowledge on how to minimize their hazardous waste and are also responsible for reporting to the authorities. Organisations dealing with hazardous waste are granskade by the authorities and also have to granska themselves. All hazardous waste in Sweden is clearly marked with a symbol. Controlling is being done by the Swedish EPA, the health authorities (national), county administrative board (regional scale) and by the municipalities (local scale). The following authorities will cooperate when necessary. If regulations are not followed and humans, animals, plants or ecosystems are in danger the crime punishment can be anything from a fine to a prison sentence (Naturvårdsverket 2003).

Transport

After waste being sorted it needs to be collected and transported to recycling facilities. 73 percent of the municipalities in Sweden are using external contractors to collect residential household waste (Avfall Sverige 2007). Municipalities can have a bonus system or a sanction in order to encourage the contractor to efficient collection and treatment of household waste. After leaving households or industries waste is transported to treatment facilities. Scandinavia has a system of few large treatment facilities and waste is often transported long distances.

From recycling stations packages are transported to collection points where materials from several recycling stations are collected. From there the material is transported to larger sorting stations or to recycling stations. There are several larger stations in Sweden that receives recycle packages.

2.4.4. Technological elements – Treatment

So, what happens to the waste once it is sorted, collected and transported to recycling facilities? The following section will briefly describe the different way of processing waste.

Incineration

Wastes that cannot be recycled in any other way are incinerated. About half of the municipal waste is incinerated, and energy is recovered either as heat or combined heat and power (Avfall Sverige, 2007). The use of technique varies, some are using grates and others use fluidized beds. Temperatures are between 850 – 1100 °C. Due to law regulations a great emphasis is put on purifying of the smoke by either dry or wet purification. Incineration facilities use multiple filters to prevent hazardous materials in the gases from being released to the air. Any by-products from incineration are separated and disposed safely (RVF 2005a).

Recycling packages

Aluminium, paper, plastics and newspaper are all transported to different facilities to be recycled into new packages. At a metallic recycling facility large machines sort the incoming waste in order to make sure that the material has a high enough quality. A mix aluminium metals are melted to liquid at 700 °C before solidification and transport to industries.

Sweden has one industry that recycles all the incoming plastics. The incoming plastics (both hard and soft) are sorted by a blowing technique. Before treatment it is crushed to small pieces and washed to remove any paper labels. The plastics are mixed with water. The mass is left to dry before it is being transported to customers.

The one paper recycling facility in Sweden recycles paper from 30 trucks every day. In a large cylinder paper is being washed with water in order to break up the paper to single paper fibres. The pulp is compressed to carton and thereafter processed in the format the clients wish. Newspapers are processed similar but the final product is newspaper.

Coloured and uncoloured glass needs to be separated to get a high quality enough of the new glass produced. Therefore they are treated in the facility every other day. In the facility glass of different sizes are mixed together, crushed and transported to different sorting machines. This is transported to glassworks where it is melted in to new glass.

Biodegradable waste

Biodegradable waste is supplied from households, restaurant, garden waste and the agro-food industry. Biodegradable waste is treated in two different ways, one being composting and the other one anaerobic digestion. In Scandinavia there are a number of facilities producing compost from biodegradable waste. Waste from households and restaurants consists mainly of food waste is normally co-composted with park and garden waste. Some facilities only accept waste in degradable paper bags. The composting is done several phases: high-rate composting, curing and then it is stored for some time, since no compost is sold during the winter months. The compost is mainly used in parks, gardens and landscaping, as well as landfill cover Very little is used in agriculture. This is partly because of quality reasons, but mainly because sectors other than agriculture are willing to pay more for the compost.

According to a study box composting is most expensive but the most efficient composting process. Emissions from compost, mostly ammoniac, methane, nitrous oxide and odour, are least when the compost is covered, which is demanded of new facilities for food waste composting (RVF 2005b).

Anaerobic digestion is used to produce biogas. Biodegradable municipal waste is often co-digested with slaughterhouse waste and other semi-liquid wastes. Common in municipalities in Sweden is that buses and also the waste trucks are run on upgraded biogas from anaerobic digestion. There is often a strict quality control of biogas plants, to enable the use of the effluent on agricultural land.

Households with gardens can take care of their own biodegradable waste and produce their own compost. The compost can be used in the garden.

A problem with composting is the odour and the attraction of rodents and households therefore need a permit for having a small compost facility for food waste, which has to be done in a closed container.

The environmental and health section of the municipality are handling the permits. Many municipalities have a system where households get a reduction of the waste collection fee and a reduced price for certified bins (Avfall Norge 2011).

2.4.5. Future trends – waste minimisation

What's next? Waste management is a never-ending story and no matter how efficient a countries waste management is there are always new technologies and ways to become even more efficient. When it comes to Scandinavia, the countries follow the directions from the EU and currently EU has a 3-year project on waste minimization. With an almost constant increase in consumption, more and more waste is being produced. Waste minimization focuses on preventing products from becoming waste.

Waste minimization is an up to date topic and there are directives from the EU that member countries should work actively to minimize the amount of waste produced. In Sweden, Denmark and Finland the authorities are spreading information to both households and industrial operators. Denmark focuses their information campaigns to the general public and schools while the Swedish EPA will publish and donate a book with information on waste minimisation to all municipalities. Finland has set a clear target and goal stating how much the amount of waste will decrease. The national waste management plan contains suggestions and ideas on preventing waste. Further they encourage the industry to improve the material productivity and have implemented a service centre to assist companies to make wiser decisions in the production process as well as for consumers to make wiser decisions such as not buy disposable novelties or rent or borrow products instead of buying new products. Some municipalities in Finland offer renting services and have also constructed workshops for repairing and laundry facilities. The most efficient tool to minimise the amount of waste is information campaigns and education, In Denmark they have established centres for trading so that functioning products taken to recycling centres can be reused. The municipalities have started an initiative where they educate and guide janitors, sanitation workers and staff at the recycling centres (Avfall Sverige 2009), Stockholm will soon have a trading centre for children toys. Even if not many trading centres are yet implemented in Scandinavia it is often mentioned when discussing waste minimization and there seems to be a trend towards it.

2.4.6. Lessons learnt from waste management in Sweden in a West African perspective

There have been various drivers for the development of policies and technologies for waste management in Sweden over the years. Some drivers are similar all over the world, whereas others that are very different from the situation in West Africa. Common drivers are:

- An interest in making better use of the resource value of waste
- An interest in finding alternatives to landfill that require less space and have less negative environmental impact
- Rising prices of energy, especially oil

Drivers present in Sweden, but not in West Africa:

- Very high costs of labor, which favors mechanization and automation
- Effective government at local and national level, including effective law enforcement

Based on those similarities and differences, some components of waste management in Sweden are relevant in West Africa, and others are not. What we see as most relevant in a West African context is the process to reduce landfilling (or dumping) of waste and increase recycling and energy recovery.

This is a long-term process; it has taken more than 20 years to abolish landfilling of mixed MSW in Sweden. Activities and strategies described above that have been part of the Swedish development that could have relevance in West Africa are

- promotion of home composting
- use of information campaigns and education in schools to promote recycling and waste reduction
- application of the polluter pays principle
    - firstly by making waste producers, including households, pay for collection and treatment of their waste,
    - secondly by differentiating fees to incorporate environmental costs and stimulate change, for example by differentiated waste collection fees designed to encourage source separation and recycling of waste
    - possibly also by producer responsibility systems
- national and local waste management plans, which describe the current situation, the goals within a 5-10 year time frame, actions needed and resources required to reach these goals
- an institution for cooperation between municipalities, which also provides links between researchers and practitioners

2.5. Examples from Switzerland (Austria)

2.5.1. Legal elements

The Federal Law on the Environment of Switzerland was promulgated in 1983. It stipulated guiding principles as (among others) the polluter-pays principle, the precautionary principle and the principle of reduction of emissions at its source. It also considered the possibility for the introduction of advanced recycling or disposal fees for wastes which require a special treatment or which are easily recyclable. It furthermore stated the need for the elaboration of district wise waste management plans.

In 1986 a general orientation and guiding principles for future waste management which was pioneering in many aspects was set-up by an expert committee. Besides arrogating the sequence of the waste hierarchy (1. avoid and minimize; 2 reuse; 3. recycle; 4. recover; 5. dispose) the agreement stated crucial requirements in the design on waste management:

- Waste disposal systems shall only produce two types of residues: recyclable residues and residues which can be disposed finally without need for long-term monitoring.
- Landfilling of endangering wastes should be done in a concentrated manner whereas environmentally not probmelatic wastes should be in a condition which is similar to the earth crust.
- Organic waste shall not be landfilled due to their long-term need for treating and monitoring effluents and gaseous emissions.
- Final disposal should only be done in monotype landfills.

It was furthermore stated that waste management should not be subsidized and the consumer costs should be related to the real costs and the risks associated with the disposal option selected. The proposed orientation was based on sustainability principles and life-cycle thinking. Legal translation of these principles took place in following years. The Technical Ordinance on Waste

which is based on the Federal Law on the Environment entered into force in 1990. From April 1996 onwards landfilling of organic waste was prohibited and incineration (with a few exceptions until the year 2000) became a legal requirement, almost 10 years before the EU introduced a similar clause.

As regards to *Waste Electrical and Electronic Equipment (WEEE)* the ordinance on the Return, the Taking Back and the Disposal of Electrical and Electronic Appliances (ORDEA) regulates the obligations for return, take-back and disposal by consumers, producers and municipalities. A technical handbook to the ordinance defines the requirements for detoxification and final disposal.

An ordinance on *Packaging Materials* aims at reducing the environmental impact of over its entire life-cycle, from production to disposal. Environmentally harmful substances are either banned by law in goods with a short lifespan such as packaging (e.g. cadmium or mercury) or by voluntary agreements (e.g. chlorine-containing plastics such as PVC). Specific, environmentally-motivated regulations apply to beverage containers (except for milk and dairy products). They aim to reduce the amounts of waste, promote the recovery of suitable beverage containers and avoid unwanted packaging materials. The ordinance sets a minimal recycling target for packaging in glass, PET and aluminium of 75%

2.5.2. Organisational elements

The planning of the *public waste management* scheme (which includes domestic, small and medium enterprise and trade waste, construction waste and hazardous waste) is done on district level, whereas the operation of the facilities falls under the municipal jurisdiction. For transportation and treatment the municipalities are cooperating in regional associations which also operate the major waste disposal plants (as for example municipal waste incinerators and landfills). The incineration plants are not privatized but in some cases are operated as private associations owned by the municipalities. Landfills for the slag and other residues from the public municipal solid waste incineration plants are mostly operated by public authorities, whereas landfills for construction waste are operated by private companies.

Industrial waste falls under the responsibility of the respective producers. The organic fraction of theses wastes is, if it is neither toxic nor hazardous, in most cases disposed of in public municipal waste incineration plants. Industrial organic waste with low hazardousness but high calorific value in some cases gets incinerated in cement kilns. The type of wastes which can be co-combusted in cement kilns is regulated in a specific guideline. Highly toxic waste is incinerated in industrial high-temperature kilns. About 80% of the hazardous waste generated in Switzerland is disposed of within the country.

Biodegradable waste mostly from urbanized centres gets collected and treated in centralized composting or anaerobic digestion plants. Some of these plants are operated by public authorities, some by private companies. Composting is done for about 85% of the separately collected biodegradable waste and about 15% enters an anaerobic digestion. About 50% of the composted or fermented biodegradable waste is generated by private households; the rest originates from street maintenance services and private companies. In small towns and rural areas decentralized composting by individuals or composting groups is promoted. However a high share of about 45% of the generated biodegradable waste in households ends up in municipal solid waste incinerators. Overall about 25% of the waste which is incinerated is biodegradable and would therefore have a fairly high potential for composting and/or fermentation.

Waste Electrical and Electronic Equipment (WEEE) is managed under the Extended Producer Responsibility concept and falls within the responsibility of producers and distributors. Collection and disposal, financed on a private-sector basis, is managed by the Swiss Foundation for the Waste Management (SENS) and the Swiss Association for Information, Communications and Organisation Technology (SWICO). Retailers, manufacturers and importers are required to take back, at no charge, those types of appliances they sell. Consumers are obliged to return appliances. It is prohibited to dispose them of via household waste. The purchase price of all

appliances covered by the respective ordinance includes a prepaid disposal charge based on voluntary sectorial agreements.

2.5.3. Logistical elements

Household waste is in most cases collected on a weekly basis by the public waste collection schemes which in towns are mostly operated by the municipalities, whereas in rural areas private transportation companies are mandated by the municipalities for this service. The waste has to be put into specific 10, 35 or 110 Litre bags or in containers. The disposed waste is either paid by volume or weight. In the case of bags these have to be bought for about USD 1.5-2 per 35 Litre bag or are charged in the case of containers on a monthly basis.

Metals, glass and PET are collected free of cost at municipal waste collection sites as it is the case in other European countries. Most municipalities offer for paper, cardboard and textiles a monthly or by-monthly door-to-door collection.

Biodegradable waste collection is offered by some town municipalities. The share of separately collected biodegradable waste is increasing. Not all towns provide this service due to the additional costs of a separate collection and other potential disturbances at the collection points.

Separate *plastic waste* collection is only done for about 10% of plastics generated in households, mainly for PET bottles. There has been a long dispute in Switzerland about the pros and contras of separate plastic waste collection from households. Major arguments for not promoting separate plastic waste collection were the costs associated with sorting the different plastic types and the quality aspects of the collected plastics. Detailed studies have shown that most of the separately collected plastics had increased heavy metal contents. This in many cases results in higher costs of recycled plastics against virgin materials.

Industrial wastes are collected and treated by the respective industries or in some cases by industry associations. A separate collection of specific plastic types from industries is in some

The take back of *Waste Electrical and Electronic Equipment (WEEE)* in Switzerland has reached 14.8 kg/inhabitant*year in 2009 which brings Switzerland among the three top level countries in Europe. This high amount is due to a highly convenient take-back system with several thousand collection points in municipalities and at retailers which are easily accessible and well known.

2.5.4. Technological elements

Separation and pre-treatment

Separation of household waste and recyclables like metal, glass, paper, cardboard, PET and textiles is done at the household level. Most Swiss municipalities offer a multi-container collection system where the recyclables are separated at the point of collection; early separation of the recyclables at household level has proven to be more cost-efficient and assure a higher quality of the recycled goods. Paper and cardboard is collected separately through a door-to-door collection.

Mechanical-biological pre-treatment of household waste prior to incineration or final disposal is not done in Switzerland. In contrast to Germany and Austria, where mechanical-biological pre-treatment is widely accepted and implemented, this technology has not entered Switzerland for various reasons. Even when such plants allow reducing the volume of the waste the resulting organic fraction from such plants is of poor quality and a high share of the produced fractions needs to be incinerated. The household waste is directed towards one of the 29 *municipal solid waste incineration* plants which are distributed over Switzerland and which all use the calorific energy of the waste for producing heat and electricity. The waste incineration plants nowadays provide about 2% of the final energy use in Switzerland. The cost for incineration are actually on average at 140 € per ton.

Fig. 18: Municipal Solid Waste Incineration Plant

Recycling and recovery

More than 50% of the generated household waste in Switzerland gets recycled. Switzerland is reaching a *recycling quota* for aluminium cans and glass above 90% and for paper, cardboard, tin and PET above 80%. For batteries this value is around 70%. With these levels Switzerland is leading in Europe. This is based on early environmental education but also due to the fact of being a small country and at the same time a touristic hotspot which favours the promotion of cleanliness of the environment. The service levels and the convenience for separating different waste fractions in an early stage are considered as key elements for reaching such high recycling quota. The financing scheme in which the discarded household waste in most of the municipalities needs to be paid per weight or volume whereas the recycled fractions can be disposed of free of cost at one of the municipal collection points or by curb side collection are important factors for incentivising separation and recycling of waste.

Material recycling of plastics as mentioned earlier is basically taking place for specific fractions like PET or monotype foils from agriculture or industrial production (like PP or PE). A separate collection of mixed plastics from households is only offered in few municipalities.

PET Recycling in Switzerland: A success story

PET Recycling Switzerland (www.petrecycling.ch) is a voluntary take-back scheme of the beverage industry. Almost all market actors participate in this scheme. The services of PET-Recycling Switzerland are financed through an advanced disposal fee (ADF) of about 1-1.5 Eurocent per bottle. The charge of the fee is based on the federal ordinance on packaging. This ordinance has set a recycling target of 75% for PET. Should this target not be reached the government could impose a mandatory deposit on PET bottles.

In about 30'000 mandatory and voluntary collection points more than 80% of about 46'000 t sold PET bottles are collected. All retailers who sell PET-bottles are obliged to take them back. Transparent bottles are recycled into new bottles whereas coloured bottles are reintegrated into other PET products. New bottles contain up to 35% recycled PET, but could thereotically be made of 100% recyclate. Recycling takes places allmost up to 100% in Switzerland.

Fig. 19: Collection bin for PET

About 110'000 tons of *Waste Electrical and Electronic Equipment (WEEE)* have entered the recycling scheme offered by the two Producer Responsibility Organizations SWICO and SENS in 2009, out of which about 4% were ICT and domestic appliances each, excluding refrigerators. The refrigerators counted for about 14% of the total quantity. In total about 70 to 75% of the processed WEEE could be directed towards material recycling.

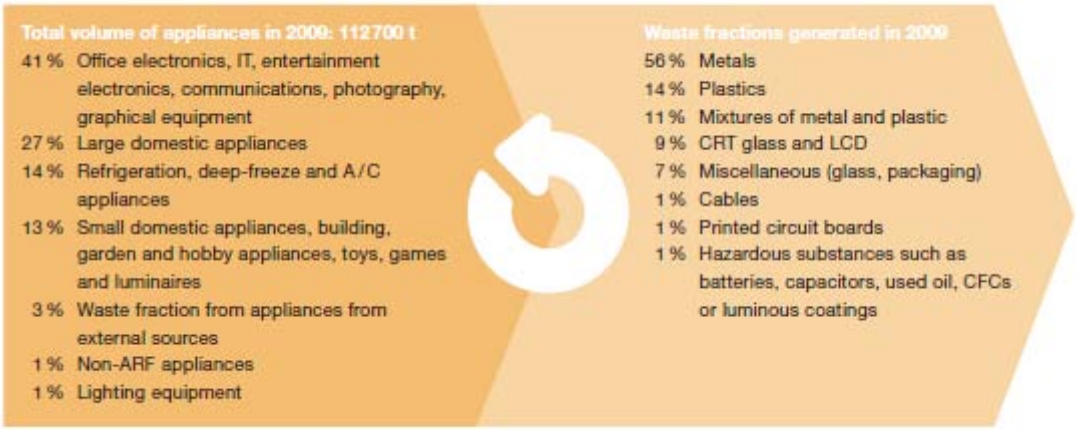

Fig. 20: Mass balance of recycling of WEEE in Switzerland

Final disposal

The Technical Ordinance on Waste (TVA) specifies rigorous requirements for waste that is to be landfilled.

Three different landfill types are distinguished:

1. Landfill for inert materials: At landfills for inert materials, only rock-like wastes may be disposed of, from which virtually no pollutants will be leached out by rainwater. These include materials such as construction waste (concrete, bricks, glass, and road rubble) and uncontaminated soil that cannot be used elsewhere. At suitable locations, landfills for inert materials do not require any special sealing. They are thus less costly and require less monitoring than other types of landfill. Guidelines issued by FOEN specify the types of waste that may be disposed of at landfills for inert materials
2. Landfill for stabilized residues: Landfills for stabilized residues are designed for the disposal of materials of known composition, with high concentrations of heavy metals and only a small organic component, and which cannot release either gases or substances readily soluble in water. Typical materials include solidified fly ash and flue gas cleaning residues from municipal waste incinerators, and vitrified treatment residues. These sites are subject to more stringent requirements than landfills for inert materials. Impermeable linings are required for the base and sides of the landfill, and leachate is to be collected and, if necessary, treated.
3. Bioactive landfill: All other types of waste suitable for landfill have to be disposed of at bioactive landfills, in which chemical and biological processes are expected to occur. At these sites, drainage controls are also required. In addition, any gases emitted are to be captured and treated. Given the unpredictable composition of their contents, bioreactor landfills are at greatest risk of requiring expensive remediation at a later date. Certain types of waste (e.g. incinerator slag) are required to be disposed of in separate compartments, isolated from other types of waste. If these wastes were intermixed, heavy metals would be leached out in much greater quantities as a result of the relatively low pH of incinerator slag. Compartments for residual wastes have also been established at numerous bioreactor landfill sites.

The Technical Ordinance on waste sets stringent limitations for landfills, covering indicators to assess the suitability of a location for a specific landfill type, limit values for the wastes accepted for landfilling and technical specifications for sealing, drainage, degasification and finalization of the landfill. For many waste types leaching tests need to be performed and strict limit values are defined. Monitoring of the landfill emissions after closure and reporting to the authorities is required, as well as the pre-financing of the costs associated with after closure care.

2.5.5. Lessons learnt from waste management in Switzerland in a West African perspective

Legal elements: The development of the legal framework in Switzerland has followed a *participative approach* which from the very beginning involved authorities and industry representation on the one hand and civil society organizations on the other. Balancing out the interests of all stakeholders from the beginning of the process increases the mutual understanding of the institutions and individuals and gives a higher acceptance of the legislative guidelines once they has been put into force. The participation of civil society organisations adds to this process a higher level of credibility and balances out partial interests of the industries and their associations. It also eased implementation of the legal framework by the authorities. The legal framework always should be based upon guiding principles and a clear assignment of responsibilities for the different processes to the involved parties.

Organisational elements: The provenance of the waste determines the way an organizational system should be designed and the responsibilities are assigned. Wastes generated by industries or complex waste streams like Waste Electrical and Electronic Equipment can be better managed by the producer of the waste than by governmental bodies. The polluter pays principle and the

Extended Producer Responsibility concept should be followed as much as possible with the government setting clear framework conditions under which the responsible bodies have to act. A clear assignment of responsibilities among national, regional and municipal authorities, private sector organisations and individuals has proven to be a key factor of success.

Waste disposal costs should reflect real costs and include for example aftercare costs of landfills and operation recycling services. Prices for waste disposal should incentivize recycling and an early separation at household level.

Logistical elements: The collection of waste should be optimized balancing out cost factors and convenience elements for the consumer. Separation should be promoted as far as possible at the source of the waste generation and circles for reintegration should be kept as small as possible. Biodegradable waste should be processed as far as possible in a decentralized system seeking low-cost solutions. Plastic waste collection should be promoted as far as possible for monotype waste only and separation should be done in an early stage in order to avoid cross-contamination by hazardous waste fractions. For hazardous and toxic waste from households special collection campaigns should be offered.

The collection system for household waste and recyclables should be built-up and operated considering settlement structures and existing door-to-door collection by waste-pickers. This will require a close collaboration with settlement organizations and the informal sector. Mechanization of the collection scheme should only start where suitability and access are assured. The selection of collection schemes for waste collection should be based upon a detailed analysis of waste types, quantities and occurrence.

Technological elements: Incineration of municipal solid waste will at most be feasible for big urban centres. Proper landfill site selection, construction, monitoring and operation are the key in order to avoid or reduce environmental impacts of landfilling. Landfill operation and emissions should be closely monitored by the authorities and remedial actions be taken in an early stage.

The promotion and authorization of waste recycling activities and reintegration of secondary resources into new products should consider the potential of cross-contamination. Plastics of Waste Electrical and Electronic Equipment for example in many cases are not suitable for reintegration into new plastic products due to their high content of heavy metals and brominated flame retardants. Plastics from mixed waste which are sorted out could potentially also be contaminated with toxics. Mechanical treatment of waste when not done properly can bear a potential for cross-contamination of secondary goods too.

2.6. Treatment of urban solid waste in France

Incinerators in France are commonly extended. In 2003, around 130 incineration plants have treated 12.6 Mt of non-dangerous waste, mainly composed of household waste (10.8 Mt), non-dangerous waste from industry, business, services (1.0 Mt), sewage sludge (0.2Mt) or clinical waste (0.1 Mt). However, incineration has negative environmental impacts because it releases polluting emissions in the air, land and water. France is developing alternatives to the incineration and buried of household garbage. Methanisation of the organic waste and mechanic selection of packaging fraction waste have been considered one of the solutions for the conservation of the environment.

The company VALORGA INTERNATIONAL (from Montepellier) has developed a methanisation process which produces compost and biogas in a cycle of a few weeks. This method is especially suitable for the treatment of all the household garbage; and not only the organic fraction; and achieves high quality compost.

The Valorga process® works in several European cities: Amiens, Calais and Varennes-Jarcy (France), Friburg, Hannover and Engelskirche (Germany), Ginebra (Switzerland), La Coruña and Barcelona (Spain), Tilburg (Pays-Bas), Mons (Belgique) in Bassano (Italy), Beijing and Shanghai (China)

2.6.1. Legal elements

The European Union (EU) has introduced measures to prevent or reduce air, water and soil pollution caused by the incineration or co-incineration of waste, as well as the resulting risk to human health. These measures specifically require a permit be obtained for incineration and co-incineration plants, and emission limits for certain pollutants released to air or to water. Directive 2000/76/EC on the incineration of waste states that "incineration of both hazardous and harmless wastes may cause emissions of substances which pollute the air, water and soil and have harmful effects on human health. In order to limit these risks, the European Union (EU) shall impose strict operating conditions and technical requirements on waste incineration plants and waste co-incineration plants". The limit values for incineration plant emissions to air are set out in Annex V to the Directive. They concern heavy metals, dioxins and furans, carbon monoxide (CO), dust, total organic carbon (TOC), hydrogen chloride (HCl), hydrogen fluoride (HF), sulphur dioxide (SO_2) and the nitrogen oxides (NO and NO_2)

Moreover, Directive 2006/12/EC of the European Parliament on waste; fixes:

The Member States shall take appropriate measures to encourage:

- The prevention or reduction of waste production and its harmfulness, in particular by:
  - The development of clean technologies more sparing in their use of natural resources;
  - The technical development and marketing of products designed so as to make no contribution or to make the smallest possible contribution, by the nature of their manufacture, use or disposal, to increasing the amount or harmfulness of waste and pollution hazards;
  - The development of appropriate techniques for the final disposal of dangerous substances contained in waste destined for recovery;
- The recovery of waste by means of recycling, reuse or reclamation or any other process with a view to extracting secondary raw materials; or
- The use of waste as a source of energy.

2.6.2. Logistical elements

2.6.2.1. Collection of waste:

The selective collection at source produces an organic fraction and a non fermentable fraction, which is composed of packaging materials: plastic, paper, iron and aluminum metals, etc.

2.6.2.2. Transportation of waste:

There is a public service of collection and transportation of waste in most of these cities mentioned above where household garbage is transported to a treatment plant. Costs of these services are purchased by the households through a waste collection fee.

2.6.3. Technological elements

The installation of a selection, methanisation and composting plant is twice cheaper than an incineration plant with the same capacity. Likewise, the running cost is a 30 or 40% cheaper, concretely around 70 Euros per ton. On the other hand, the combination of methanisation and final composting enables to get high quality compost for its use in agriculture in a minor period of time.

2.6.3.1. Technologies for separation

The separation process performs an efficient waste sorting which depends on human training and the technology used. At first, waste is separated manually in a conveyor belt. With that purpose, a selection machine has been designed by the company TRISELEC. The system blows and vibrates

at same time, which allows the separation of waste in fractions: glass, aluminum, plastics and the rest fraction; it manages 70 tons per hour with reliability of 3 per 1000. Finally, the process ends with a manual selection.

Fig. 21: Waste sorting machine designed by TRISELEC.

2.6.3.2. Technologies for treatment

The process *Valorga* has three main elements:

→ The initial separation of the different fractions of waste.

→ The methanisation is the anaerobic fast degradation of the organic fraction.

→ The final composting.

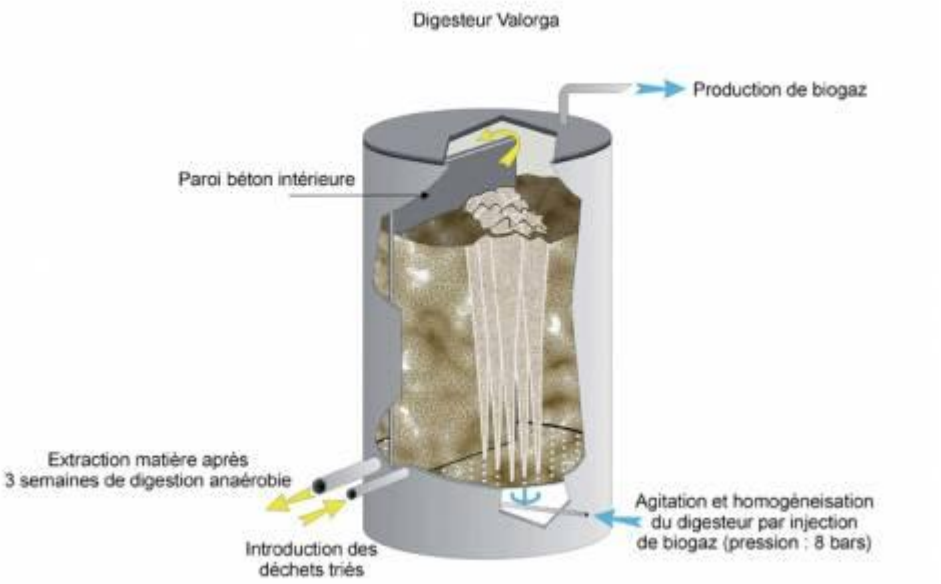

Fig. 22: Diagram of a methanisation reactor without mechanic pieces (VALORGA INTERNACIONAL)

The biogas is originated in the bioreactor from the fermentation of waste. The biogas produced is injected in order to start the movement of waste, shake and homogenize it. Waste seeps into the

reactor continuously during all the work time and it is pushed by the biogas, easing the composting process. The waste remains within the reactor during 3 weeks to complete its fermentation.

The biogas produced during this time, is recovered for providing heat or electricity.

For example, the Varennes-Jarcy plant started running in 2007; it treats 70.000 tons of urban waste per year; and 30.000 tons of organic waste. At the end of the process, it has been recovered 40.000 tons of compost and 11 millions of m^3 of biogas.

2.6.3.3. Technologies for recovery/recycling and disposal

The company TRISELEC is the responsible of recovery and recycling of the rest fraction; they transform the non organic waste in package of papers, aluminum or plastics. The glass is sold to the glass industry. This is the treatment for the 89% of the waste, the rest of them are sent to landfills or incineration plants.

Compost and biogas obtained from the anaerobic digestion process in the bioreactor are transformed into energy and fertilizer. Residues which can not be treated are transported to incineration plants. These plants fulfil the current European legal framework and have a treatment system which generated in 2003 3.0 Mt of bottom ash of which 2.3 Mt were used for roads construction and 0.2 Mt of ferrous and non-ferrous metal were recycled. It also produced 2,900,000MWh of electricity, of which 2,200,000 MWh were sold to Electricité de France (EDF) and 9,100,000 MWh of heat, of which 7,200,000 MWh were sold to private or public users.

However, by-products of incinerating waste, in particular air emissions, can include carbon dioxide, acid gas, particulate matter, heavy metals (example: mercury), highly toxic trace organic compounds and dioxins, all of which has a negative impact on the environment.

2.6.4. Organizational elements

The anaerobic digestion process described in this section has been implemented by VALORGA INTERNATIONAL, a private company specialized in the conception, build-up and start-up of installations of biological waste treatment for municipalities and industry. The company is contracted by local governments in order to develop an activity of design- construction of Municipal Solid Waste treatment plants including the anaerobic digestion of the organic matter.

They also ensure the transfer of knowledge and the acquisition of know-how for the owners of their installations as well as provide with advice, audit and expertise. Bringing together these activities enables them to multiply synergies effectively.

The anaerobic digestion process implemented consists in bringing a relevant solution in the following four domains of application:

- the methanisation of the biowaste resulting from a source-sorted collection generating an organic high-quality compost,
- the treatment of the organic fraction issued from household waste generating a compost which can be marketed in agriculture,
- the biological stabilization of residual household waste, generating a stabilized product for landfills,
- The co-digestion of sewage sludge, oils, vegetable fats or any other organic substrates with the organic fraction from MSW.

Two important steps lead up to the successes of their development:

- A research and development phase in laboratory followed by a process fine-tuning on industrialized pilot during the first seven years,
- An industrial development of the *Valorga* process® all over the world lasts for 18 years.

3. EXPERIENCES IN AFRICA – EXAMPLES FOR SUCCESSFUL ISWM SYSTEMS

3.1. Examples from Egypt (further Arabian states in Africa)

3.1.1. Successful technologies

3.1.1.1. Nasria Hazardous Waste Management Project in Alexandria [Example 1]

Hazardous wastes in Alexandria had formerly been a growing environmental pressure with now system to handle it before establishing the first treatment facility. It was established under the Hazardous Waste Management Project (HWMP) in Alexandria; a two-phase joint project between Egypt and Finland. It was initiated in 1999 and officially inaugurated in 2005. The Egyptian Environmental Affairs Agency, Governorate of Alexandria and the Ministry for Foreign Affairs of Finland are the counterparts in the project. The project provides the first treatment facility since the Egyptian Environment Law number 4 of 1994 came in to force, the Nasreya Hazardous Waste Treatment Centre. It is expected to improve prospects for enforcement of the regulatory requirements specified in the law.

The Governorate of Alexandria has formed a Hazardous Waste Management Unit (HWMU) in 2000, under which the Nasreya Hazardous Waste Treatment Centre operates.

Phase I of the facility includes a secure landfill and solar evaporation ponds to receive wastes, and Phase II includes mechanical and chemical treatment, solidification, and interim storage. The facilities consist of the following key items:

- Fenced landfill area of 14,000 square meters designed in accordance with the international standards,
- Administration building, security offices, and a chemical laboratory Security office,
- Evaporation ponds with an area of 5,000 square meter for leachate from the landfill, rainwater and neutral water from the physical chemical treatment plant,
- Weighing bridge, a maintenance workshop and garage,
- Groundwater monitoring wells,
- Washing station for transport vehicles,
- Electricity generator,
- Physical chemical treatment unit,
- Solidification unit,
- Inorganic hazardous waste storage area,
- Organic hazardous waste transfer station

Organic hazardous waste is conditionally received if a pre-set destination is determined.

Today, the success of this initiative has paved the way to venture into new projects that are currently ongoing for Compact Fluorescent Light bulbs (CFL) Recycling in cooperation with the Korean International Cooperation Agency, and also plastic recycling in cooperation with Alexandria University.

3.1.1.2. Landfill Gas Capture & Flaring in Alexandria, Egypt [Example 2]

This project includes two recently constructed municipal waste landfills in Alexandria, Egypt which are part of the global waste management system initiated by the Alexandria Governorate. Firstly, the Borg El Arab Landfill was originally designed for the disposal of waste collected from Alexandria. The governorate generates about 3,000 TPD of municipal waste from the residential areas, and commercial, industrial, and medical establishments. Waste is collected directly or through three transfer stations. A comprehensive waste management system was initiated in 2000

and was intended to improve the quality of life for the city's 5 million residents. Later, in 2003, the Governorate of Alexandria requested Onyx Alexandria, a subsidiary of Veolia, to open a second landfill in El Hammam, 30 km south of Borg El Arab. Approximately 13 million tonnes of waste will be deposited in the two landfills over the contract term. The term is a 15-year period, serving 18 districts within the city for cleaning, collection, landfilling and treatment.

The technology that is new to the region is the capture of landfill gas (LFG) from the two new landfill sites, reducing greenhouse gas and hazardous emissions. The project entails the installation of enhanced landfill gas extraction and flaring equipment for the destruction of the landfill methane that is collected from the existing and future disposal areas instead of releasing it to the atmosphere. Onyx Alexandria has obtained an ISO 9001 certificate in December 2004 and the ISO 14001 (Environment) and 18001 (Safety) in August 2005, showing commitment to environmental and quality responsibilities. The components of the project are as follows:

- A composite liner system (geomembrane / geotextile) and leachate collection system will be installed as landfilling progresses.
- Final cover soils will be placed when leveling with the ground.
- Completed sections will be re-vegetated.
- Landfill gas (LFG) recovery equipment will be installed, being the first in Egypt.
- An onsite evaporator to use the collected landfill methane as a fuel to evaporate the leachate collected from the existing and future lined disposal areas.
- Excess landfill gas is flared and therefore reduces the greenhouse gas emissions.

As a result of GHG reductions achieved with this system (LFG recovery, utilization, and flaring), the project qualified as a Clean Development Mechanism (CDM) project and was registered in the United Nation Framework Convention for Climate Change (UNFCCC) in 2006. CDM registration allows the project to gain further revenue through selling Certified Emission Reductions (CERs) generated with time, estimated to be 370,903 CERs annually in average over the crediting period.

3.1.1.3. Informal Sector and APE in Garbage City [Example 3]

The Association for the Protection of the Environment (A.P.E) is an Egyptian NGO, concerned with upgrading the inhabitants of the traditional waste collectors (the Zabbaleen) in Cairo, alternatively known as Garbage City, through an integrated approach. The approach aims to support entire families through training on waste recycling practices. For women, a revolving fund was established to offer micro-loans for women and young girls to learn handcrafts. They were trained on making traditional carpets, table mats, hand bags, etc, using textile trimmings and wastes. They also recycle waste paper to produce postal cards, envelopes, page markers, and various other items. Men on the other hand work on waste recycling using heavy machineries such as plastic granulators, plastic injection molding machines, film making machines, extruders and other specialized equipment. The association started 1983 and continues today to offer hundreds of employment opportunities, contributing to the welfare of the vulnerable local community and women, and mainstreaming education and awareness into their activities.

3.1.1.4. MANAGEM and Al-Jisr "GREEN CHIP" Project in Morocco [Example 4]

In Morocco, disposal of 1500 tons of waste generated by the ICT industry has grown dramatically in recent years. In the meantime waste recovery can convert this waste into valuable products. In December 2009 a partnership agreement was made between Managem in Morocco and Al Jisr Association to develop the so-called *Green Chip* project for the collection of used digital equipment and E-waste recycling. The project incorporates the social components, including training and awareness.

Today, Al Jisr Association, through the Green Chip project, collects, dismantles and sorts e-waste. A dedicated entity, CTT, promotes the products dismantled: recovery of precious and nonferrous metals and sale of other products dismantled such as steel, plastics, and other elements. Furthermore 65 underprivileged youth are trained each year in computer maintenance and receive a technical diploma in computer maintenance. This increases their chances for employment and helps them create their own microenterprises. 7,000 personal computers will be upgraded by the students and made available to the public schools in rural areas, through sponsorships schools and businesses.

The Swiss Foundation, Drosos, is the main financial contributor to the project (15 MUSD) and ensures strict monitoring and evaluation. Drossos audited CTT before funding Al Jisr.

Furthermore, the Department of Employment and Vocational Training has approved the Training and Education Center of Al Jisr and provided financial support. The Ministry of National Education, through the Academy of Greater Casablanca, provided 300 sq ft of land, located at the Lycée Moulay Abdallah, to establish the Center and to appoint a technical director and two accountants.

3.1.2. Best organizational practices

3.1.2.1. Local Management through Hemaya CBO in Sinai [Example 1]

Nuweiba, a coastal city on the Gulf of Aqaba in Sinai is one of the most beautiful tourism spots in the world, known for its colorful coral reefs, marine life, and pristine coastal environment. It is home to a unique Bedouin community. Tourism and population growth has created an environmental pressure with time, evident in the increased littering and poorly managed waste prior to the establishment of an effective SWM system.

For this purpose, Hemaya, meaning 'Protection' in Arabic, a community-based organization (CBO), was established by social entrepreneur Eng. Sherif El Ghamrawy in 1997 to test an innovative solution. He introduced a locally managed approach to garbage disposal that creates jobs and capitalizes on the collection and resale of recyclable materials. It engages the local community in maintaining clean streets and building a full community investment in waste management.

Building on his experience in establishing one of Egypt’s first ecotourism lodges, El-Ghamrawy rapidly developed Hemaya and sought financial and political support to build a regional waste transfer station. He then recruited and trained local citizens to collect and sort waste. In later stages he won contracts from local hotels and the City Council to collect and transport the majority of garbage in Sinai. The local community through Hemaya was able to take the first step toward institutionalization by partnering with the more experienced NGO's in the field of solid waste management systems, and also partnering with the local municipality and the private sector. It brought the South Sinai municipalities, together with the expertise of the Association for the Protection of the Environment (A.P.E.), the Hemaya NGO, the A.P.E. Dahab branch, and the Bedouins in the area as well as the hotel industry, all engaged in the common goal of creating a sustainable SWM system. The model demonstrated how local management can be an effective alternative to the costly foreign companies that were monopolizing waste management elsewhere in Egypt with comparatively poor performance.

Today, Hemaya continues to collect the dry fraction (plastics, paper, textile, and metal), while the Bedouins typically sort out the organic material to feed their cattle and birds. Baled products are sold to waste dealers and recycling factories in Cairo. The model is locally and internationally recognized as a success and is subject to expansion and replication.

3.1.2.2. Advent of Private Sector ONYX in Alexandria [Example 2]

The waste collection system formerly adopted in Alexandria consisted of central government acquiring trucks for local government councils to collect, as in the rest of Egypt, and with little concern over uncontrolled disposal. When the system proved inefficient, the government later resorted to privatization of waste services. Privatization was initially to local companies, and after poor performance, the governorate of Alexandria decided in year 2000 to resort to international tendering of the service. This also involved the introduction of sanitary landfills as a new component, since uncontrolled dumpsites had become a common nuisance in many parts of Egypt. Alexandria was the first to take this step in Egypt, and this move promised to improve SWM and transfer new technology to the nation.

Onyx won the first contract in Alexandria to have a comprehensive and integrated waste collection and disposal service to the Governorate of Alexandria. This consisted of street sweeping and waste collection from the residential areas, commercial, industrial and medical establishments, and cleaning public facilities (e.g. bus stations, squares, fountains, etc), and waste treatment and landfilling. It aims to recycle 20% of the received wastes.

With support of international development agencies, a Contract Monitoring Unit was established to oversee the implementation of the work plan as agreed upon between the governorate and the international winners: in the case of Alexandria, Onyx (Veolia) in 2000 and in the case of Cairo, two Spanish firms and one Italian firm in 2002. The governorates are vested with the authority to negotiate and contract waste management services to private operators. They are authorized to collect a fee-for-service to support them in meeting their contractual obligations toward the private operator. With time, more consideration and acknowledgement of the informal sector has slowly moved toward creating a reasonable balance between interests of the various stakeholders and the vulnerable communities previously dependant on the informal waste industry.

3.1.2.3. SWM in Rural Governorate El-Menia [Example 3]

Minya Governorate, 245 Km south Cairo, was selected to be one of the projects to receive the support of the Egyptian Italian Environmental Cooperation Project for the development of its SWM system in response to the great development need in the governorate. The project, initiated in 2001, established an independent SWM Organizational Structure to be a pilot project for the other rural governorates. It was part of a Debt SWAP program, whereby projects are implemented by the host country in return for national debt deductions. Minya consists of nine Markazes (every Markaz is made of a city, mother villages, and satellites). The project had selected two persons from each Markaz, trained 9 in the job workshops, visited five best cases in Egypt and three in Italy, and carried out ten different SWM sector studies (e.g. waste generation, collection, transportation, hydro-geology, financial, organizational, social, etc) to all the nine cities. The findings of these studies have been collected into geo-referenced databases to support future planning and monitoring. The new management reports directly to the secretary general of the governorate and the system is operating successfully.

3.1.2.4. ANGED Project in Tunis [Example 4]

The National Agency for Waste Management (ANGED), Créée par le décret n°2317 du 22 Août 2005,l'Agence Nationale de Gestion des Déchets (ANGED) est un établissement public à caractère non administratif placé sous tutelle du Ministère de l'Environnement et du Développement Durable. Elle est chargée notamment des missions suivantes: known in Tunis as “Agence National des Dechets”, is a specialized public agency established in Tunis in 2005. ANGED is under the Ministry of Environment and sustainable development. It is responsible for the following tasks:

- Participate in the development of national programs for waste management.
- The construction and execution of projects and procedures enshrined in national waste management.

- Contribute to support and strengthen regional groupings or structures that local authorities create in the field of sustainable management of works and landfills.
- Provide technical assistance in the industrial areas of waste management.
- Systems-management of public waste management (plastic packaging, lubricating oils, used oil filters, batteries, etc...)
- Promote collection programs for recycling and recovery of waste.
- Manage and maintain hazardous waste management activities.
- Participate in research for waste management studies.

Several programs have been achieved to date by ANGED (Ministry of Environment of Tunis, 2010):

- The management of household and similar waste, through the establishment of a network of 10 landfills and 48 transfer stations in exploitation and additional 10 landfills and 60 transfer stations under building, to reduce the rate of household waste management in landfills by 45% in 2007 to 93% in 2011.
- The management of industrial waste through the implementation of a specialized landfill in 2007 in Jradou (Zaghouan) and three transfer stations covering the entire country and allowing the processing of approximately 60% of industrial and special waste.
- The establishment of a system of sustainable management of hospital waste
- Development of channels of collection and recycling, including waste plastics, batteries and accumulators, waste oils.
- The valorization of organic waste to produce electricity

ANGED is expected to continue playing a leading role in implementing the government policy for the sustainable development of the ISWM sector in Tunis.

3.2. Examples from South Africa

3.2.1. Successful technologies

3.2.1.1. Decentralized Composting [Example 1]

Decentralized composting (Figure) is an option for organic waste treatment that has been applied in developing countries like India (Zurbrügg et al., 2004) and Cuba (Körner et al., 2008). For Bangladesh, Waste Concern, a research based NGO, joined efforts with communities to create a community-based decentralized composting project in Mirpur, Dhaka. The composting system started its activities in 1995 with the plan of developing a low-cost method for composting of MSW with creation of job opportunities for the urban poor (Zurbrügg et al., 2005).

The composting is made using the “Indonesian Windrow Technique”, a thermophilic and aerobic manual procedure. The composting scheme was formally approved by the Bangladesh Agriculture Research Council on the use of the compost product for agricultural purposes and had policy support from the Ministry of Agriculture. Waste Concern works in partnership with local authorities, private sector, local communities and international agencies (Zurbrügg et al., 2005).

Collected mixed household waste is pre-sorted at the composting site, before composting. The design capacity of 3 tons/day was reached by the end of 2001, being responsible for the waste treatment produced by 1,430 households. About 10 people are employed at the composting plant. The financial success of the system is due to the fact that large bulk buyers of compost exist: the compost product is mainly sold to fertilizer producing companies. Those companies combine the compost with additives/nutrients to suit different customers (Zurbrügg et al., 2005).

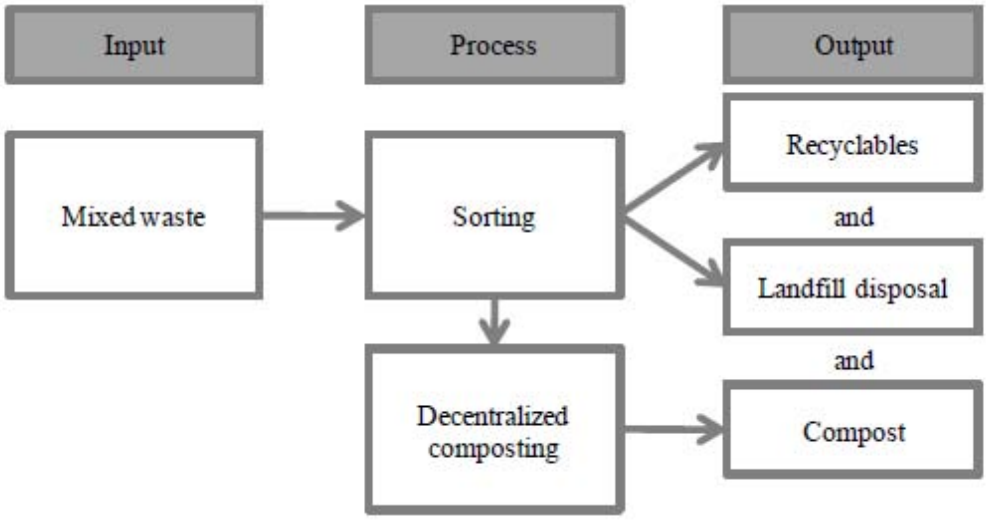

Fig. 23: Decentralized composting process with its inputs and outputs

3.2.1.2. Urban composting in South Africa – sustainability aspects [Example 2]

Some municipal initiatives in composting of solid waste in South Africa were studied, and based on these seven case studies, an evaluation of how composting fulfils the goals of the municipalities was done. The goals were technological process function, environmental impact, economic sustainability and social policy fulfilment. The quality of the end product varied, depending on incoming material, waste pre-treatment and level of process control. All projects produced a product that had a market, with end users ranging from municipal projects to homeowners and

organic farmers. Very little was done to prevent environmental impacts of the visited compost projects, due to the relatively small environmental impact of the composts, together with insufficient reinforcement of the environmental legislation. None of the visited projects was yet economically self-sustainable, partly because most of the projects had not been running for very long. The private companies saw great potential in the business and hoped to break even soon. By valuing the alternative costs or external benefits, the municipal projects considered the costs for the composting projects to be acceptable. There was an over all high awareness of the importance to fulfil social policy goals, but the strategies differed between organisations, and the projects with municipal involvement were more ambitious.

3.2.1.3. The Kraaifontein Integrated Waste Management Facility (IWMF), City of Cape Town [Example 3]

The Kraaifontein IWMF located in the metropolitan municipality of Cape Town is a multifunctional 'one stop' centralised waste treatment, recycling and recovery facility for all types of household waste.

It includes a public drop-off site for recyclables (including electronic waste and household hazardous waste), a materials recovery, sorting and baling facility ('Clean' MRF) for previously source-separated household recyclables and a transfer station where unsorted and/or non-recyclable fractions are compacted into containers before the waste is transferred to a landfill for disposal. It also contains an area where green waste chipping activities take place to manufacture compost.

The ZAR 200 million (USD 28.6 million[7]) facility does not accept large loads of builders rubble, any sewage sludge or other hazardous or medical waste. The transfer station unit has a waste capacity of 960 tons per day equivalent to the household waste generated by 960,000 people. This means that the facility has the potential to process about 20% of Cape Town's waste on a daily basis. The 'clean' MRF combines manual sorting along a conveyor belt and basic mechanical extraction i.e. a magnet for cans and a weight separation technology for plastic bags and pieces of paper.

3.2.1.4. The Think Twice Household Recycling Initiative, City of Cape Town [Example 4]

An estimated 80% of high to medium income household wastes comprises reusable/recyclable materials. In 2007, a public-private partnership based on a pilot household recycling collection system under the name of "Think Twice" was introduced into six areas across the City of Cape Town (covering about 9% of all Cape Town formal households). Appointed contractors issue participating households with a clear plastic bag for clean, flattened, dry recyclable waste while the wet (putrescible) waste component is placed in a black plastic bag. The private contractors collect the recyclable fraction on a weekly basis, on the same day as the municipal waste, and transport it to privately-owned Material Recovery Facilities (MRF) where it is further sorted into different categories for downstream recycling.

Three contractors currently service a total of 70 000 households (with 40,000 more to be included to feed the Kraaifontein MRF). It is estimated that the Think Twice initiative recovers about 9,000 tons of recyclables annually directly from households. This represents only about 0.45% of Cape Town's overall current recycling rate and therefore comes at a very high price (as discussed under the organisational section below).

3.2.1.5. The Mariannhill Landfill Site, eThekwini Metropolitan Municipality [Example 5]

The Mariannhill Landfill in a residential area of eThekwini Metropolitan Municipality (Durban) is managed by the waste management arm of the municipality, Durban Solid Waste (DSW). It is

[7] Exchange Rate: USD 1 = ZAR 7.

operated to a very high standard which reduces its impacts on the surrounding environment and communities. It is registered as a National Conservancy and is possibly the only landfill in Africa with environmental conservancy status.

Some of the noteworthy features of the landfill include:

- A Plant Rescue Unit ('Prunit') where indigenous plants and seeds, which would otherwise have been lost because they were within the area to be landfilled, are rescued, propagated and stored at a holding nursery on site. Plants from the unit are used for the rehabilitation of buffer areas along the landfill periphery as well as at other landfill rehabilitation works in the municipality.
- A Leachate Treatment Plant that treats the leachate to within the limits of the discharge standards required by the national water authority for discharge of wastewater by irrigation. The leachate is first treated by a Sequencing Batch Reactor unit followed by secondary "polishing" treatment by an artificial reed bed, from where it either goes to sewer or it is used on site for dust control.
- A landfill gas to electricity project which comprises a gas extraction and flaring system together with gas engines that use the methane gas to generate electricity. The system supplies 1 megawatt of electricity to the municipal electricity grid.
- A bird hide and wetland above the site to attenuate storm water runoff around the site.
- An educational centre that hosts groups of schoolchildren and students on a weekly basis to explain the features of the landfill and promote good waste management practices
- Until recently, the landfill also had a Materials Recovery Facility (MRF), owned by DSW but operated by a private recycling company on site. The incoming mixed domestic waste was sorted both manually and mechanically (magnet and trommel) and baled plastic (PET, polypropylene, polystyrene, polyethylene), paper (office white, K4/cardboard) and steel cans. Glass was also collected and stored in skips. This was a pilot project that operated productively until its closure toward the end of 2010. The facility diverted 30% by volume of the domestic waste stream collected by the DSW collection fleet from landfill, or approximately 10% by mass of the total waste stream entering the site.

3.2.1.6. The eThekwini Durban Solid Waste / Munitech Community Waste Collection System [Example 6]

The eThekwini Community Waste Collection System was developed as an alternative method of service delivery for people living in the heavily populated less formal settlement in Inanda, KwaMashu and Umlazi in eThekwini Metropolitan Municipality. A community contractor, appointed by DSW, collects and takes the waste to a skip at a secondary collection site. The municipality then collects and transports the skip with an appropriate vehicle to the municipal disposal site. The system was managed and administered by a management consulting firm, Munitech.

The three main technical factors determining the size of contract are the number of households that a community contractor can service per day (limited by terrain and access); the type of vehicle used; and the distance to the disposal site/transfer station which determines the vehicle turn-around time. This number can vary from anywhere between 200 dwellings to 10,000 dwellings per week.

Contracts were generally zoned to conform to municipal ward boundaries which simplified the community consultation processes. Each contract is sized on the basis of full utilisation of one primary and one secondary collection unit and a task of approximately 1,000 to 1,500 households per primary collection unit per day. This ensures a high degree of utilisation of each contractor's fixed resources (vehicle, overheads, labour etc.) and ensures that unit costs are kept low. Contractors hand out refuse bags, collect refuse, clean streets and open areas, clear stockpiles and illegal dumps, clear the open street drains and maintain street verges in their contract zones.

This achieves exceptionally high levels of cleanliness because the contractor is accountable for the total cleanliness of the area and develops a sense of ownership and pride in the contract area. Two different types of contract were selected to accommodate different contracting capabilities:-

- Community Waste Contracts are comprehensive contracts to collect all waste from the specified area and transport it to the disposal site. This type of contract was targeted at emerging contractors who had access to sufficient resources to operate a refuse collection vehicle and to supply all equipment necessary to provide a comprehensive service.
- Labour-only contracts where the contractor removes all waste in the serviced area to bulk containers placed in the contract zone at a frequency of approximately one container per 250 houses. The contractor only provides labour as there is no need for a vehicle; refuse bags and equipment are provided by DSW.

In 2001, 17 comprehensive contracts, 3 skip-clearing contracts and 15 labour-only contracts were in place. Refuse collection is inherently labor intensive in informal communities where waste has to be carried to the bulk containers. It is estimated that these services provided employment for 600 people on a sustainable basis and that more than 80% of these jobs were filled by people resident in the respective contract zones. Contractors were required, in terms of the contracts, to meet certain minimum standards in respect of employment and working conditions to avoid the exploitation of labour.

The cost per household of around USD 2.5 to USD 3.7 per month is achieved with the Community Waste Contractor in the eThekwini Metro and is considered to be relatively low when compared with similar services being provided in other areas.

3.2.2. Best organizational practices

3.2.2.1. The Kraaifontein Integrated Waste Management Facility (IWMF), City of Cape Town [Example 1]

The development of the Kraaifontein IWMF was based on a feasibility study conducted in June 1999, an economic viability study in May 2006 and a full Environmental Impact Assessment (EIA) prior to its construction. The City of Cape Town built the MRF costing around USD 28.6 million of public funds (tax payers money). In addition the City of Cape Town successfully applied for MIG (Municipal Infrastructural Grant) funded from National Treasury

A recent specialist re-assessment of the City of Cape Town's Municipal Systems Act (MSA) Section 78(3) was done in order to investigate how "waste minimisation" – as required by both the National Waste Act and the City of Cape Town's own Waste By-Law - can be introduced into the City's existing historical line functions namely "cleansing, collection and disposal".

To fulfil both the mandate of waste minimisation, while satisfying the labour unions requirement for existing jobs within the City of Cape Town to be maintained (even if retraining might be required) the recommendation was given that the City of Cape Town remain legally responsible and (bound by the MSA) to manage waste for disposal but that as soon as opportunities arise from any type of waste benefits (e.g. including, but not limited to, recycling of materials, composting of greens, crushing of builders rubble etc) the City should seek the involvement of the private sector through public private partnerships or by outsourcing the activities.

At the moment the Kraaifontein facility is run entirely by City of Cape Town but the Solid Waste Management department intends to outsource the operation of the Drop-Off site (including the handling of the accepted household hazardous waste which is a first for Cape Town), the 'Clean' MRF and the Greens Chipping area to specialist private service providers. Only the transfer station for waste going to landfill will then be operated by the City itself. The e-Waste Alliance NGO has applied for permission to remove e-waste from the drop off facility for repair, refurbishment and/or dismantling. A Service Level Agreement is currently being drawn up between the City and the NGO.

Internal audits are conducted every second month and an external audit will be conducted every fourth month. The facility has a monitoring committee made up of representatives from surrounding communities.

3.2.2.2. The Think Twice Household Recycling Initiative, City of Cape Town [Example 2]

This collection and sorting service for mixed recyclables for medium to high income households in Cape Town is financed by the City of Cape Town (through taxpayers money) and implemented by three private waste management contractors appointed through a tender process. Tender specifications included the development of their own MRF facility as well as provision of collection vehicles suited to collect mixed recyclables in a safe and efficient manner. As part of the contract each of the three contractors has to raise public awareness in their contract area, do regular marketing and communication with the participants as soon programmes are rolled out, and report on statistics of how much was collected, and what the participation rates were. A unique tender specification is that appointed contractors have participation targets of a minimum of 50% of householders in the contract area and tonnage targets of at least 12.5% of the total of the collected waste from household, otherwise financial penalties apply.

With regard to financing the Think Twice project, it has become evident that, in line with the principle of Extended Producer Responsibility, costs should be shared by the private sector as there is a commercially viable market for recycled materials, but at the same time management costs clearly exceed potential revenues (see costing analysis below).

Financial Consideration and Costing of Think Twice

The revenue earned on a bag of mixed recyclables varies between ZAR 0.60 and ZAR 0.70 per kg (USD 0.08 and USD 0.10). The average cost of collecting such recyclables from households exceeds any revenue gained because transport and collection costs alone are in the range of ZAR 0.80 - ZAR 1.00 per kg (USD 0.11 and USD 0.14). This cost excludes any labour costs for sorting the recyclables at the privately-owned MRFs.

Collection and landfill disposal of a ton of general waste (excluding transport cost) costs the city in the region of ZAR 200 (USD 28). The cost of recovering recyclables in Think Twice areas can be as high as ZAR 1,800/ton (USD 257/ton). The project also only works in fairly high income areas where the waste stream contains higher quantities of recoverable materials and a groundswell of environmental awareness exists to achieve high participation rates. Some areas have reached an 80% participation target. While there is pressure from politicians to roll out the service throughout the city including informal areas in the name of ‘service equity‘, the real cost of source separation will make this difficult. The Solid Waste Department has nevertheless indicated that it would bring in another 40,000 high-income households to feed the new Kraaifontein ’Clean’ MRF. Recent studies showed that if this waste were to go to a municipal-owned MRF, the costs would reduce dramatically to about ZAR 700/ton (USD 100/ton).

3.2.2.3. The WasteWise Campaign, City of Cape Town [Example 3]

WasteWise is the City of Cape Town’s official public awareness programme which does not contain any technological elements but offers an interesting case study on an organisational structure of a tri-partite partnership model.

The programme raises awareness and encourages action amongst communities, schools, commerce and industry and the general public of Cape Town to minimise waste, reduce littering, stop illegal dumping, and increase recycling. WasteWise seeks to foster behaviour change and a culture of joint environmental responsibility amongst all residents to reduce waste to landfill and empower citizens to minimize waste and littering. It provides information, materials and training for businesses, commerce and other organisations on how to comply with the City’s new by-laws. Its key emphasis is to create long-term tri-partite working relationships between WasteWise (eco) schools/communities, local business/industry and the City of Cape Town, to develop and establish triple-bottom line, sustainable waste minimisation and social up liftment programmes as in fig. 24.

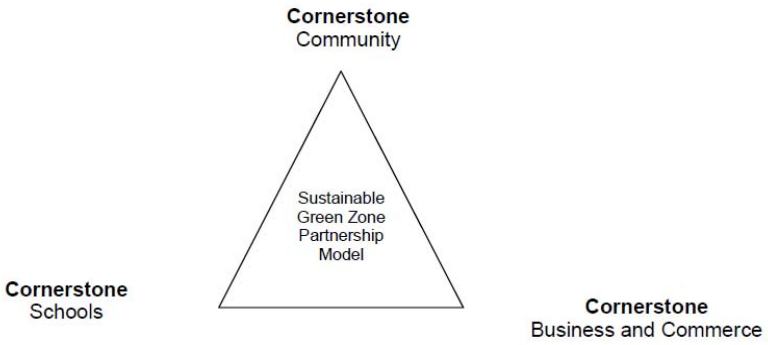

Fig. 24: Tripartite Partnership Model applied to strengthen sustainability of waste education and activity programmes

The City has changed its role to one of enabler and networker, promoting the strategy of partnering with local businesses within the WasteWise target zones to sponsor WasteWise interventions.

Businesses increasingly highlight their involvement of environmental and social stewardship programmes such as WasteWise in their Annual Sustainability reports and market this as part of their Corporate Social Responsibility initiatives. WasteWise partnerships have benefits of involvement in new business opportunities, growing their customer base, while positively impacting on surrounding communities and schools.

3.2.2.4. The e-Waste Alliance Model (eWA), City of Cape Town [Example 4]

In South Africa an industry-initiated and financed take-back scheme for electronic waste has been formulated and an administering non-profit organisation, the e-Waste Association of South Africa (eWASA), has been campaigning for over five years now for the establishment of a 'Green Fee'. This fee is to be raised on import of electronic goods and used to appoint accredited service providers for the safe dismantling of all e-waste therefore subsidizing in particular the components with no or negative market value (such as CRT monitors).

The e-Waste Alliance is a non-profit organisation to address the need for practical e-waste management solutions for both businesses and households. Currently six different independent and locally based SMMEs are members of eWA and a facilitator coordinates integrated management of any type of e-waste in a one-stop shop format and in accordance with exact client requirements.

The objectives of the eWA are to:

- Minimise waste and maximise resource use and job creation/entrepreneurship opportunities
- Add value in each step of the e-waste treatment hierarchy
- Give preference to the recovery of function of equipment where possible before optimising the recovery of materials for further downstream recycling and rework (development of 'waste2art' options).
- Become a blueprint for a viable e-waste management system elsewhere in (South) Africa

The organisation of eWA is structured to promote the sharing of crucial knowledge on best prices, infrastructure, waste disposal arrangements etc amongst the members who therefore support each other's operations, especially in difficult economic times. Most members fulfil multiple functions, doing repair and refurbishment while dismantling at the same time. One company even has a 'waste2art' section which manufactures very upmarket, attractive clocks from computer hard drives. By offering to collect from businesses and households either free or at the lowest possible cost, or buying directly from trolley collectors (at around ZAR 0.70 /kg) material is redirected from an uncontrolled and unsafe informal environment into the formal sector.

Best locally available practice and technologies are applied at all times (such as safe disposal of hazardous components at authorized hazardous landfills) but the challenge for the eWA members is to compete with the big e-waste recycling businesses that can offer large companies a single, national contract. There is as also a growing number of informal recyclers that selectively remove the few valuable components and leave the rest behind with no consideration for the environment.

Economic situation

While refurbishment of electronic equipment in South Africa generally does not require external support or motivation, the long term economic viability of safe dismantling activities that offer fair labour and wage conditions is more of a challenge. eWA members struggle to operate basic dismantling units at the safety standards required by the corporate electronic firms, and therefore cannot easily access the more lucrative and more regular business e-waste streams. Three of the companies that have ventured into dismantling manage to break-even but another incurred a significant loss so decided to stop dismantling and focus on e-waste collection only.

The quantities of e-Waste collected are often not enough in the absence of regular e-waste revenue streams. A single person can fully process between 80 and 100 kg per day, i.e. 1.8 to 2.2 tons per person per month. Experience by eWA members shows that rentals, transport and labour costs significantly erode any potential profits. The break-even point for an economically viable dismantling operation is around 15 tons per month and the activity only really becomes lucrative when process volumes reach 20 tons per month. Further challenges in the current economic climate are volatility in the demand for recovered material (e.g. plastic) and the small profit margins in dismantling due to low prices paid from local monopolistic down-stream recyclers and refineries.

E-waste from household sources is generally not of high value. Householders tend to stockpile e-waste and are unwilling to release it unless they are paid for it. The transport, treatment and labour costs plus disposal costs for the hazardous components make it very difficult in the South African climate to make dismantling viable on its own. In conclusion, therefore, while there is value in some e-waste it is not advisable to subject its downstream management simply to 'free market forces'. Unless there is an industry-financed and managed take-back model, the valuable components will be removed selectively and the toxic residual waste will be left behind. The Extended Producer Responsibility principle should be enforced by National Government to address this.

3.2.2.5. Mariannhill Landfill, eThekwini Metropolitan Municipality [Example 5]

The success of the Mariannhill Landfill operations can be attributed largely to the commitment and enthusiasm of the management team that is responsible for the running of the site. The landfill is managed as a business and not a free-for-all dumping ground, unlike many of the landfill sites operated by the public sector in South Africa which do not monitor the incoming waste or charge landfill fees.

Durban Solid Waste keeps up to date with trends in the waste management sector and exceeds the standards required for operating the site. They have been forward-thinking in terms of new projects: they were the first to extract landfill gas and install gas to electricity engines at the two main municipal landfills in eThekwini. They are recovering revenue from selling electricity to the municipal grid as well as CDM credits.

Lessons learned at the Mariannhill Materials Recovery Facility

Lessons can be learned from the reasons for the private recycling company having to close down the operation of the Mariannhill MRF:

- The space allocated by DSW to this operation limited the quantities of waste that could be processed. The large quantity of recyclables in the general industrial waste entering the site, which constituted nearly 50% of all the waste entering the landfill, could therefore not be recovered.
- Material from this MRF was sold to traders in the Peoples' Republic of China but the volatility experienced during the 2009 global recession had a severe negative impact. In

order to remain viable, it was critical to recover at least 100 tons per day of clean recyclables.

- The MRF was upgraded and a new pre-sort line was introduced to improve picking efficiencies and increase the volumes processed per hour. The staff complement was increased from 100 to 180, mainly unskilled, people to work at the sorting conveyors and other skilled operators to operate and maintain the conveyors and balers, and a second shift was introduced. Once the upgrade was completed and the staff employed, the additional volumes were still not achieved.
- The recycling company also requested a share of the disposal fees recovered by DSW at the weighbridge in recognition of the savings on airspace and landfilling costs, however there were constraints on doing this in terms of municipal financing procedures.
- The percentage of cleaner recyclable material in the domestic waste stream declined a result of a different source separation, kerbside collection program for recyclable material being initiated in the same higher income waste catchment area as for the landfill. This significantly reduced the quality and quantities of recyclables recoverable at the MRF.

3.2.2.6. The eThekwini Durban Solid Waste / Munitech Community Waste Collection System [Example 6]

The success of community collection system eThekwini Metropolitan Municipality relates to the institutional arrangements around how the contracts are awarded and managed. The tender process is made accessible to emerging contractors through workshops during the tendering process on business planning and tendering techniques and support to contractors during the early stages of tendering to link them with financial institutions, register them with the relevant government departments, assist them to develop business plans and provide on-going on-the-job business advice.

The contracts are strictly administered, while providing the support to ensure a rapid transfer of skills and the development of internal capacity in respect of waste collection contracting the need for this capacity development has decreased since this system was introduced because there is now a sufficiently large pool of competent tenderers. The education wing of DSW employs locally based Community Development Workers to actively seek the support of key community structures and individuals through visiting households to explain the use and benefits of the available services whilst implementing community education and incentive programmes

With these contracts, the cleanliness in most of the formal and informal communities is of an exceptionally high standard and is comparable with that in the established formal suburbs of Durban. The success was attributed to:-

- the effort applied to ensure that contractors achieve adequate levels of competence
- contract zoning and the design of the scheme
- contractors being held responsible and accountable for the cleanliness of their areas
- the intensity of inspection and supervision
- contract structure and the way in which measurement and payment is dealt with in the contract
- Community co-operation and improving levels of awareness

Lessons learned:

- Costs must be recovered through a combination of the rates and service charges system of the Council, subsidy from government and a degree of cross-subsidisation from waste collection revenues received from service charges to business.
- Communities must co-operate with the service with awareness programmes maintaining high levels of community support.
- Adequate levels of supervision and administration must ensure that contractors perform in accordance with contract requirements
- Contractors must develop and retain the capability to deliver the services in accordance with their contracts.
- The appointment of a specialised facilitatory management consultant by DSW was a major contributing factor to the success of the system. This management contract included planning, management, administration and supervision of the scheme and the individual contracts and the development and implementation of an information system-based administration and supervision programme. Ongoing support and monitoring of contractors enhanced the sustainability of the scheme.

Constraints to implementation will be encountered if an existing system or work-force would need to be displaced to accommodate the implementation of this restructured scheme: it is best introduced into areas where no service yet exists.

3.2.2.7. Formalization of Emfuleni Local Municipality Waste Reclaimers – Palm Springs Landfill [Example 7]

The presence of informal waste reclaimers on waste disposal sites, common in developing countries, raises concerns around the health and safety of the workers –both the landfill employees and the reclaimers themselves. Landfill operators are also extremely cautious as they may be held liable for damages, should an accident occur. In some cases the permits or licences of facilities prohibit waste reclaimers from working on site. Therefore, allowing them on site would mean the operator of the site would be in violation of the permit conditions and could face action from the authorities. Many landfill operators, however, allow reclaiming as it helps to extend landfill space and provides work and income for reclaimers.

In the case of Palm Springs Landfill in the Emfuleni Local Municipality, reclaimers were already on site when a new superintendent took over the operations of the landfill facilities in the municipality in 2006. He sought to improve the situation of the waste pickers by negotiating with them and helping them to formalize their activities. The key aspects of the model included the following:-

- Waste pickers were required to register with the municipality and were issued with identification cards so that landfill staff knew who should be allowed on site.
- The workers were arranged into groups: young women, old women, young men, and old men. The groups had rotating access to trucks that come onto site which gave equal opportunities to women or older men who would not have to compete with younger men for materials when it was their turn.
- The superintendent created a separate sorting and storage area for each waste reclaimer, demarcated by mounds of earth, thus preventing disputes and bringing a level of organization to their operations.
- Each of the four groups elected two members onto a steering committee as a way of self-regulating themselves. The steering committee addressed issues and disputes, made sure that workers were abiding by the rules and imposing penalties for failing to do so e.g. placing a ban on operating on site for a period of time depending on the extent of the offence.

Not many landfills have been able to replicate the success of the Emfuleni reclaimers even at other landfills in the same municipality. The reason for this was that the landfill supervisor was not as hands-on as the superintendent who was always on site at the Palm Springs Landfill. This highlights the importance of the role played by the landfill operator and staff in organising the

reclaimers. It requires someone who is passionate about waste management, sympathetic to the plight of waste reclaimers, but who also has strong leadership abilities.

3.3. Examples from Nigeria

3.3.1. Successful technologies

Technologies currently employed in Nigeria for SWM management are discussed below:

3.3.1.1. Primary collection

The use of road side waste collection bin or sacs is most common in both rural and urban areas of the country; there is no segregation of municipal and no special container for hazardous waste. All type is co-disposed. Householder or commercial institutions use whatever they find appropriate. Similarly construction and location of transfer station is not according to a standard or pattern or specification. Presently, only Lagos state is making progress towards sound environmental management of SW. Infrastructure to collect the waste leads to accumulation of wastes in the streets of the country.

Fig. 25: Common collection containers in Nigeria

3.3.1.2. Transportation

All types of vehicles and wheel barrows or hand push carts are utilized to transport solid waste from its generation point to the transfer station; and from there to the treatment or disposal sites. In Lagos State there are Compactor Vehicle which is used for collection, Long trailer/Walking flaw trailers are used for Transfer station, Automated Static Compacting vehicle are used in loading at Transfer station, Landfill Compactor are used for land filling.

3.3.1.3. Treatment

The major waste treatment employed in the country is open burning of the wastes at backyards, roadsides, illegal and legal dumpsites. However, recovery and recycling of plastic and organic wastes take place in some parts of the country. The main constrain being lack of separation of wastes at sources. A number of informal separation also occurs at dumpsites all over the cities.

Fig. 26: Open burning practices

3.3.1.4. Final Disposal

Open dumpsites is the common facility for final disposal of wastes in Nigeria as opposed to the sanitary landfill practised in the advanced countries of the world. The waste management authorities in each state have designated sites for dumping and there are several undesignated areas within the metropolis where dumping occurs without any check.

3.3.2. Best organizational practices

A typical solid waste management system in a developing country displays an array of problems, including inadequate funding, low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control, the breeding of flies and vermin, and the handling and control of informal waste picking or scavenging activities. Legislation related to solid waste management in developing countries is usually fragmented, and several laws (e.g., Public Health Act, Local Government Act, Environmental Protection Act, etc.) include some clauses on rules/regulations regarding solid waste management. The rules and regulations are enforced by the different agencies. However, there are often duplication of responsibilities of the agencies involved and gaps/missing elements in the regulatory provisions for the development of effective solid waste management systems. It should be also noted that legislation is only effective if it is enforced

Nigeria is a nation made up of thirty-six states and the federal capital territory practices the federal system of government. The apex body on environmental matters is the federal Ministry of Environment and its agency, the National Environmental Standards and Regulations Enforcement Agency. Each state is mainly responsible for its own environmental issues under various environmental and town planning laws.

The constitutional framework for environmental management in Nigeria is very centralized. The federal and state governments are given the primary responsibility for developing and applying the legislative framework for environmental management and provision of supervisory and regulatory functions, while the primary responsibility for economic planning and development lies with the local governments.

At the state level, institutions responsible for waste management are the statutory bodies made up of the Ministry, agency and boards or authorities and the Quasi permanent bodies made up of task forces and project monitoring units

The highly centralized institutional framework for environmental management in Nigeria has resulted in inconsistent policy framework that lacked an integrated approach. Consequently there are institutional overlaps and associated problems such as inadequate resources and role conflicts resulting in piles of solid waste.

In Lagos state, the Ministry of the Environment is the apex body on environmental matters. The Lagos State Environmental Protection Agency (LASEPA) and the Lagos State Waste Management Authority (LAWMA) are agencies under the Lagos state ministry of Ministry.

The Ministry is saddled with the responsibility of policy making and ensuring the implementation of policies through effective monitoring of waste management facilities and Private Operators in waste collection and hauling in the State. LASEPA is saddled with the responsibility of protecting the environment while the Management LAWMA is charged with the responsibilities of achieving in partnership with the Private Sector, a cleaner, healthier and aesthetic environment through improved waste collection, transportation and disposal of solid waste. The Agency is presently taking care of refuse on highways, markets, hospitals, industrial and commercial areas and also supervising over 116 Private Sector Participant (PSP) operators who operate as private refuse collectors and are registered by the ministry under the restructured mega Private Sector programme.

The Ministry which was previously in charge of the reviewed PSP programme has transferred this responsibility to LAWMA. These PSP’s are involved in the collection, transportation, treatment, disposal and recycling of solid waste.

The organized private investors are fully incorporated into solid waste collection through PSP by the Lagos State Government. About 400 private firms are so far licensed by the government with about 15,000 people gainfully engaged under the scheme. They include truck drivers and their assistants, supervisors, office/account clerks, waste loaders and highway sweepers.

Private investors are also a part of waste management in Lagos state. Some of the investors are; Earthcare which is managing a composting plant in Ikorodu area of the state, private refuse collectors, Jebba paper mills and Ojo plastic recycling plant.

Also an integrated and modern solid waste management project capable of processing 180,000 tons of waste for reuse through recycling and composting is soon to take off in Lagos. The project is to be completed via Finance, Design, Build, Operate and Transfer (FDBOT) structure by the private sector under a 20 year Concession agreement for the development of a comprehensive project which includes closure, collection and utilization of landfill gas (LFG) at the two existing dumpsites while incorporating a Clean Development Mechanism(CDM) Financing Structure. The project also includes the establishment of an Integrated Solid Waste Management Facility (IWMF) comprising of a Material Recovery Facility (MRF), Recycling and Composting Facility as well as a sanitary (Bale fill) landfill for residual waste.

LAWMA has some technical partners supporting its operation these are the World Bank, United State Trade and Development Agency (USTDA), United Nations Development Programme (UNDP), Department For International Development (DFID), Clinton Foundation (Clinton Climate Initiative) and Indigenous Banks.

In summary some of the factors responsible for the level of success LAWMA has achieved are: Having LAWMA as the sole agency implementing solid waste management in the state; Involvement of the private sector in various sectors of solid waste management; generation of income from the creation of employment, and from reuse and recycling of waste materials; Involvement of foreign partners resulting in transfer and dissipation of knowledge and technology and investment in best practice of environmentally sound management of waste.

All of these combined has brought in more funds and more investments, increased waste to wealth, increased gainful employment and has a greater positive impact on the environment.

In conclusion, Lagos State Government has continued to develop new strategies for effective waste management this no doubt account for the influx of experts from other states in the country and Africa countries including (Ghana, Sierra Leone, Côte d'Ivoire Senegal and Ethiopia) to under study its Waste Management System and solicit for partnership.

The state now has the record of being the African's biggest producer of compost (Organic Fertilizer) at 250 bags/day to recycling of 50 tons of nylon & plastic (pure water sachets and PET bottles), paper bailing etc, all of these are in line with the plan of the Lagos State Government, to position itself as the emerging centre of excellence for solid waste management in Africa.

4. EXPERIENCES WITH SUBSTANCE BANS AND ALTERNATIVE APPROACHES

4.1. Introduction

This chapter accesses the experiences made with substance bans of the EU legislation, such as Restriction of Hazardous Substance Directive (RoHS) for electrical and electronics equipment. Furthermore alternative approaches for legal substance bans will be analyzed. These contain voluntary industry agreements, code of conducts and labelling schemes for electrical and electronic products. Finally, recommendations will be made based on a comparison of different approaches with regard to their feasibility for the target countries of IWWA.

4.2. Substance bans in the EC regulation

On 1 July 2006, the **Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC (RoHS directive)** took effect in the European Union, restricting the use of six hazardous[8] materials in electrical and electronics equipment. The six hazardous materials are lead, mercury, cadmium, hexavalent chromium (Cr^{6+}), polybrominated biphenyls and polybrominated diphenyl ether[9]. The potential environmental impacts of the hazardous substances are:

- Contamination of freshwater sources and sediments
- Contamination of soils
- Contamination of air
- Human health impacts

Those environmental pollutions are caused by unqualified treatment of waste electrical and electronic equipment (WEEE), such as open burning, uncontrolled dumping and the use of hazardous chemicals for the recycling of precious metals (Widmer et al., (2005).

The directive forces legally electrical and electronic industry to take full responsibility to green electronics worldwide, since it applies also to imported products from non-EU-member states and not just to those produced in the EU. A common way to ensure RoHS compliance is to obtain declarations for materials, components and other parts from suppliers (Michel et al., 2008).

The **EU regulation on Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)** entered into force on June 1, 2007. It requires certain chemical information to be supplied to recipients and consumers and to notify the European Chemicals Agency (ECHA) on articles containing substances of very high concern (SVHC) listed on the candidate list[10]. If a substance on the candidate list exceeds the concentration of 0.1 % weight in the article (i.e. product), the recipient needs to be informed immediately. If in addition, the quantity of such a substance contained in all articles of a legal entity exceeds the tonnage of 1 ton per year, notification to ECHA becomes mandatory (as of June 1, 2011). (IPC 28.04.2009)

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[8] According to the EC Directive 92/32/EEC substances and preparations are "dangerous" if they are explosive, oxidizing, flammable, toxic, harmful, corrosive, irritant, sensitizing, carcinogenic, mutagenic, toxic for reproduction or dangerous for the environment. (EC (1992))

[9] During the ongoing recast the scope of the RoHS Directive will be widened from a specific list of items to all electrical and electronic appliances – unless specifically excluded. Furthermore the European Commission will conduct a review of the blacklist and evaluate a number of substances that are not currently restricted, including three phtalates (a plastic softener) and one brominated flame retardant. (EurActiv (2010))

[10] The candidate list can be found here:

http://echa.europa.eu/chem_data/authorisation_process/ candidate_list_table_en.asp.

The German electronics industry association BITKOM recommends electrical and electronic equipment manufacturers (BITKOM 2008)

- check if a product contains substances of the candidate list. If that is the case, the company can decide, not to utilize the substance, to substitute it with another non candidate substance or to alter the product's design to be independent of that substance.
- create an inventory of all substances used in the products of the company and to demand such information from the supplier and importers up the value chain ("Ask your supplier!")
- tinform the trading companies and customers by including a link in the product documentation/user manual to a website with more information on REACh

The REACh directive applies to articles, which intend to release a substance under normal or reasonably foreseeable conditions of use (e.g. ink cartridge). If "the producer or importer can exclude exposure to humans or the environment during normal or reasonably foreseeable conditions of use including disposal" (Article 7), the Agency must not be informed. Therefore some argues, that electrical and electronic components and products are not subject to REACh, because they do not intentionally release substances.

4.3. NIGERIA'S EXPERIENCES WITH SUBSTANCE BANS BY THE EC

4.3.1. Introduction

The European Union (EU) is taking measures to prevent the generation of electrical and electronic waste and to promote reuse, recycling and other forms of recovery in order to reduce the quantity of such waste to be eliminated, whilst also improving the environmental performance of economic operators involved in its management. In addition, in order to contribute to the recovery and elimination of equipment waste and the protection of human health, the EU is also taking measures to restrict the use of hazardous substances in this type of equipment.

The EC directive on waste electrical and electronic equipment (WEEE) applies to the following categories of electrical and electronic equipment: large and small household appliances, IT and telecommunications equipment, consumer equipment, lighting equipment, electrical and electronic tools (with the exception of large-scale stationary industrial tools), toys, leisure and sports equipment, medical devices (with the exception of implanted and infected products), monitoring and control instruments and automatic dispensers.

4.3.2. Ban substances in Nigeria

Sources of information on the status of WEEE ban in the country were gathered through manifests of shipments of electronics into Nigeria, data from the National Bureau of Statistics, Nigerian Customs Service and administration of questionnaires on various stakeholders and consumers and literature search through the net. Interview of stakeholders, Inspections and on-the-spot evaluations were carried out at selected port terminals, and bonded terminals to observe the category, quality, quantity, brands, as well as modes of importation of electronics etc.

The EC ban substances observed in Nigeria with penetration rates includes large household appliances (refrigerator (30.7%), air conditioner (23.7%)) small household appliances (iron (31.5%)), information and communication technologies (computer (27.2%), laptop (35.8%), mobile phones (47.1%) and television set (27.6%). They enter into Nigeria as new, second hand, repairable and used and end-of-life electronic products. A lot of this equipment has reached the end of life before reaching Nigeria.

Country of importation

The main sources of importation of used and end-of-life electronic and electrical equipment (EEE) to Nigeria are European countries, China, USA and Japan. About 75.01% of the imported containers of used electronic products are from Europe, 9% from China, 3% from United States, 2.3% from Japan and about 4% from Morocco.

Modes and point of entry

The major ports of origin for used EEE imported into Nigeria are as shown in the table below

Table 6: Country of Importation of EEE

Country	Ports	Number of containers	Percentage (%)
United Kingdom	Tilbury, Roydon Sussex Tilbury, Heinfield West Sussex, Felixstowe	104	59.1
Germany	Hamburg	28	15.91
US	Boston, Norfolk, Baltimore	5	2.84
Hong Kong	Shekou	2	1.14
China	Shanghai	15	8.52
Japan	Osaka, Yokohama Kanaga	4	2.27
Durban- South Africa		1	0.57
Taiwan	Port Kelany	6	3.40
Lebanon	Beirut	1	0.57
Canada	Montreal	1	0.57
Morocco	Tangier	7	3.98
Belgium	Antwerp	2	1.14
Total		145	100

They enter and leave Nigeria through ECOWAS states via land boarders (e.g Seme Boarder) and sea ports and from developed countries through international airports (Murtala International airport) and sea ports (Apapa and Tincan Port).

- More used EEE are imported through the sea ports (TinCan Port) than new EEE.
- Analysis of the data from 18 manifest (18 ships that arrived Tin Can port between January-March, 2010) shows that 145 containers of used EEE were imported as against 116 containers of new EEE.

Modes of importation of used EEE through the sea ports

Used EEE are imported in to the country through declaration as personal effects, in containers, in used vehicles that come to the country through the sea ports, by concealing or mixing with other items.

Table 7. Comparative analysis of importation of new and used EEE into Nigeria

S/N	Description	Number	Percentage
1	No of ships without EEE on board	2	11.11%
2	No of ships with new EEE on board	9	50.0%
3	No of ships with used EEE on board	14	77.78%
4	No of ships with new and used EEE on board	16	88.89%
5	No of ships with only used EEE on board	7	38.88%
6	No of ships with only new EEE on board	2	11.11%

Table 8. Total quantity of imported and locally produced electrical equipments

Electrical equipments	Total quantity imports	Total quantity locally produced	Total available product
Television	264,548	15,237	279,785
Extension Boxes	32,208		32,208
Air Conditioner	81,601	95,904	177,505
Telephone and parts	8,000		8,000
Kitchen/oven	10,734		10,734
Fans	294,380		294,380
Refigerators	73,426	124,781	198,207
Radio sets	11,190	2,554,592	2,565,782
Computers	23,2633		232,633
Water dispensers	39,388		39,388
Loud Speakers	555,129	555,129	
Radio Cassettes	130,820	130,820	
Electrical Cables	17,590	175,90	

Manufacturing, distribution, consumption of EEE and e-waste management outlets in Nigeria

System overview of key players involved in EEE management in Nigeria and their relationship to each other in the mass flows of electronics in Nigeria is shown in the figure below.

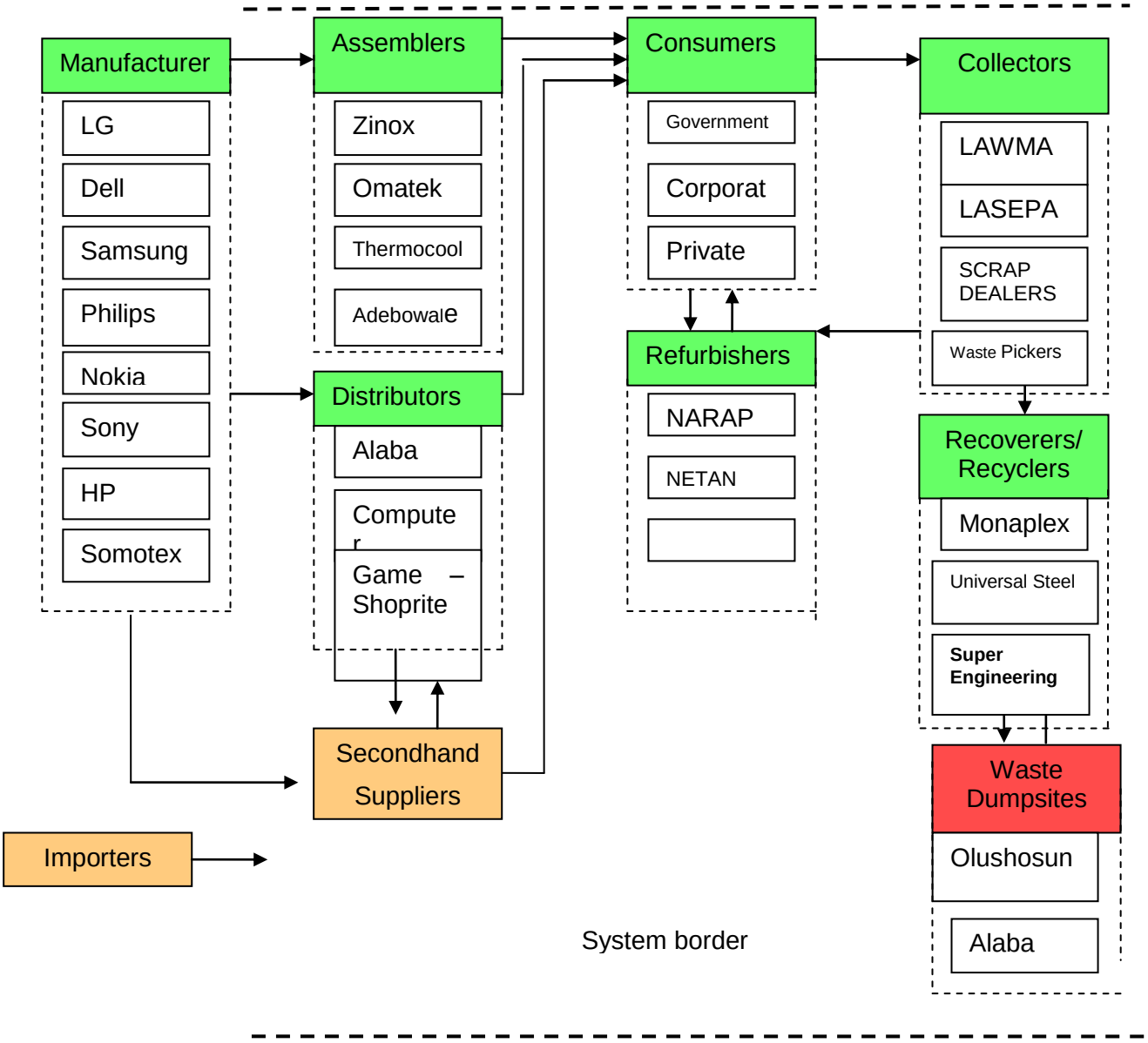

Fig. 27: Stakeholder overview in EEE Management in Nigeria

Table 9. Overview of key manufacturer of EEE in Nigeria

Organisation	Types of EEE being Handled in Nigeria
Adebowale Electronics	White goods and electrical lightings
Dell	Computers
HP	Computers
LG	Large and Small house hold appliances
Nokia	Mobile Phones
Omatek	Computers, & Power Products
Somotex	Small Household Appliance and electrical lightings
Samsung	Large and Small Household Appliances, computers and mobile phones
Sony	Large and Small Household Appliance, Computers and mobile phones
Zinox	Computers

Table 10. Consumption patterns

EEE	Government	Private	Others
Computer	4100	10387	24
Printer	2216	4438	7
Telephone	452	5451	49
Television	242	10489	41
Refrigerators	2130	4719	27

4.3.3. WEEE management in Nigeria

4.3.3.1. Modes of end of life management

The modes of end of life management of electronics and electrical equipment in Nigeria starts with repairs/ refurbishment and once discarded as unwanted it often get to be stored in a corner or a storage area, where it may or may not be inventoried and finally it gets to be disposed off. In Corporate Organizations EEE is kept in stores, underneath the staircases. In the communities they are dumped in the streets with other types of waste.

Fig. 28: Dumping of EEE by streets with other types of waste

4.3.3.2. Repairs/ refurbishment

The refurbishers refurbish new EEE that got damaged by uncontrolled voltage, end-of-life and second hand products. The importer after sorting the good functional ones from the faulty ones sold the faulty ones as non-tested which the customer after purchase gives to a refurbisher /repairer. Among the non-tested found to be unserviceable are dismantled and the good components are removed to serve as spare parts.

There are both formal and informal repair/refurbishment organisations in the country. Major formal refurbishment is by a few organisations which provide repair services for the products of major original equipment manufacturers (OEMs). Most of the manufacturer representatives /Importers provide the services centre. These are located at Ikeja computer village, Alaba markets and some designated centre where electrical/electronic equipments can be repaired.

The informal sector does minor repairs where major spare parts are not required using one part of a defective electronic product to repair another to make it work. The group of informal refurbishers are organised in to associations in both market (Alaba and the computer village ikeja) and across the country. Some work within neighbourhoods and some go to corporate organisations to repair faulty electrical/ electronic equipments. The results of survey revealed that most refurbishers are involved in the refurbishing of household consumer electronic goods (TV, radio, DVD, CD players etc) which makes up 62.5% of all refurbishers; followed by refurbishers of mobile phones (25%) and refurbishers of computers/printers/scanners and related computer accessories (12.5%). Approximately 66-68% of EEE brought to repairers and refurbishers shops are effectively repaired. An estimated 52,000 persons are engaged in the refurbishing business in Nigeria.

A typical repair shop receives between 20-50 equipments daily and equipments beyond repairs are dismantled and some useful parts used to fix other equipments. The e-waste produced in standard repair shop is about 300-500 kg/year.

The repair shops sometimes serve as a dumping ground for used and broken equipments before final disposal. 12-25% of the refurbishers dispose all e-waste generated in their operations with general waste. Others estimated at 66% store and sell the waste to collectors while the useless wastes are disposed with general waste. Some burn wastes generated during the refurbishers activities within their business operation area. Other dumps the waste around the business premises and at open dumps.

Most repairers at the market visited were not protected with protective wear while working. From the survey result, 67.6% were unaware of the environmental hazards caused by discarded electronic equipment and as such were unaware that some hazardous fractions such as Pb, Cd, Ni, Cu as well as brominated flame retardants (BFRs) in e-waste need a special treatment in order to be safely disposed off.

4.3.3.3. Collection

Collection of e-waste is through the formal and informal organisations. The formal collection system accounts for about 20% while 80% is done by the informal sector. The main sources of collected materials are homes/dumpsites, refurbishers' workshops, streets and from importers.

The informal sector is the major collector through waste pickers (scavengers) and scrap dealers agents scattered across the states of the country. The waste pickers collect all recyclable waste generally from the households at a price or pick from those dumped with domestic waste. Hand-picked e-wastes, kept in sacs, transported by wheel barrows or hand push carts to where they are sold at some designated places to some brokers who dismantle the wastes to extract the materials identified with most economic value. Collectors indicated that the destinations of e-waste are Onitsha, Lagos, Warri and Kano. Between 144 kg/wk and 1985 kg/wk of e-waste mixed with other metal scraps is collected by a scavenger. The collected e-waste is co-mingled with other metal scrap. Up to 80,000 persons (34,000-80,000) are involved in this sector in Nigeria. There is exposure of workers in the informal sector to the hazardous substances in the e-waste due to lack/non-use of personal protective equipment/wares during the dismantling processes.

The examples of formal organisations involved in e-waste collection in Nigeria are the Lagos State Waste Management Authority (LAWMA) and Lagos State Environmental Protection Agency (LASEPA) through a consultant under a public private partnership arrangement. Currently the e wastes collected are kept apart in a section of the dump site managed by the LAWMA. The e-waste collected by the consultant working with LASEPA, MSC (maintenance system consultancy) is kept in a warehouse in anticipation of a recycling activity. Currently no money is being charged for the evacuation by LASEPA consultant, thus creating an incentive for the corporate organisation to declare the e-waste stockpile and get them ready for evacuation.

4.3.3.4. Recyclers

Presently, there is no formal recycler of e-waste in the country. Those who are engaged in it are in the informal sector. The informal recyclers are spread all over the country. The major ones in Lagos are located in Alaba rago, Olusosun dumpsite and Odo Iya alaro at Ojota while Sabongari serves as the hub for those in Kano. This sector comprises of mainly individuals with only few registered operators. An estimate of the national average on the basis of interview in the cities assessed indicates the sector employs an estimated 72,000 to 100,800 persons throughout the country.

Only a very small share of the WEEE is recycled. Recycling technologies applied are crude methods i.e. manual dismantling using hammers and other simple tools, breaking, grinding or processing of the material fractions and open burning of Waste cables with tyres to retrieve copper wire.

Computer cables, plastics from TV sets, CRTs from TV sets, computer monitors, transformer from EEE, condenser and compressor of refrigerator as well as printed wiring boards (PWBs)/PCBs (printed circuit boards) are different types of EEE recycled. From the estimates derived from the interviews of recyclers in the course of the survey, between 46,276 tons and 1,347,840 tons of scrap metals are handled annually in the country.

Fractions and by-products produced in the recycling process are copper wire, aluminium scrap metal, iron scrap metal, gold and plastics. The fractions recovered are sold to Downstream Vendors who supply them to manufacturing industries as secondary raw materials locally. The iron parts are sold to local iron smelters and other steel companies in the country. Aluminium fractions are sold to Tower aluminium in Lagos. Plastic parts are sold to plastic companies. Some of the identified companies involved in e-waste and metals recycling in Nigeria are: Metalphic, Sunflag, Universal Steel, Ikorodu and African Steel all in Lagos, Aladja Steel in Warri, Ajaokuta Steel Company, Nigerian Spanish metal in Kano and other marketers in Onitsha.

There are indications that certain categories of e-waste are exported especially PWB and copper wires. The collectors indicated that they are exported to China and other Asian countries. The copper, gold, brass and silver are bought by traders of the northern extraction who supply dealers in Mali through the land borders and these are then exported to china. Printed wiring boards from e-waste are sold to a few foreigners who export them to formal recyclers in Europe to recover precious metals such as gold.

Most of the recyclers are not aware of proper disposal methods. The non- valuable fraction (hazardous/non-hazardous) plastic fractions including the ash from the burning activities are either disposed with MSW or burn off in the dark hours after government officials close of work or abandoned on site.

4.3.3.5. Final disposal

E waste disposal generally in the country is often co-disposed with municipal waste in officially designated open dumpsites owned by government. The organizations in charge of the final disposal of across the country are the state waste management authorities that are not only involved in regulatory function but also serve as service providers in disposal of both municipal and e-waste. Other than the official designated dumpsites there are some illegal waste dumpsite scattered where open burning takes place in the country.

4.3.3.6. Potential impact to human health and the environment

Most e-waste activities take place within inhabited areas. The collectors, refurbishes and even recyclers usually have their site within residential area. Most affected communities are those residing within e-waste generation and management areas. From the survey carried out in Lagos, the most affected communities are those in the environ of the Alaba International market, Ikeja Computer Village, Odo iya Alaro and Olushosun dump sites with area of influence of pollution spreading to the Ojota, Ikeja and Alaba axis. In the other cities surveyed e-waste is burnt along with municipal waste at dumpsites.

E-waste management activities impacted negatively on the resident, by affecting the air water and soil. Unusable e –waste are carelessly dumped around these communities and occasionally burnt to reduce growing piles. Furthermore the discharges from the dismantling and breaking operations are spilled onto the surrounding soils. These contaminate the soil and nearby water bodies through storm water flow. The burning activities also release highly toxic fumes. Soil samples collected from the upper 0-100 cm of soil at e-waste recovery sites indicates that at some points the upper 100cm profile composed of ash and cinder mixed with soil. Consequently the sector poses serious health and environmental risk to immediate and neighbouring communities with the attendant air, water and soil contamination. There was visible soil, water and air contamination

The-waste contains toxic heavy metals such as Pb, Cd,Ni, Be, Hg and hazardous chemicals like brominated flame retardants (BFRs) that are handled by workers, some of them children. Informal

processing of electronic waste in developing countries causes serious health and pollution problems.

4.4. Alternative approaches

Beyond the ban of hazardous substance by legal restrictions a wide range of alternative solutions exist. The following sections review some of the most promising approaches for the target countries in detail. The most widely used alternatives to reduce the environmental impacts of products in Europe are:

- Eco-labels
- Individual manufacturer policies
- Voluntary industry agreements
- Procurement policies: Green Public Procurement, Green Purchasing
- Third party assessment on toxicity and life cycle impacts
- Voluntary take back systems from individual producers or collection schemes from a industry association

4.4.1. Eco-Labels

Eco-Lables certify the low impact of a product or service on the environment. They might have a double focus on

- a range of products and
- a given geographic area

Two common product-related European eco-labels which also award electronic and electrical equipment (EEE) are the European Ecolabel and the German Blue Angel:

Fig. 29: Logo of the European Ecolabel and the German Blue Angel

The Blue Angel - a product-related label – shows the environmental benefits of a product. Below the logo you can see, which of the four categories “climate”, “health”, “water” and “resources” is protected be the product. At the moment 11,500 products from about 1,050 companies in 90 different product groups exist. There are requirements for every one of about 30 electronic product groups such as “computer keyboards”, “laptops”, “mobile phones” and “washing machines”.
The Blue Angel Eco-label of electronic products addresses in general:

- Power consumption
- Longevity, upgradability, principles of recycling design as well as potential reuse and recycling of used products or product components
- Use of environmentally harmful substances
- Noise

- User information

The more specific requirements for computers address that:

- no PBBs (polybrominated biphenyls), PBDEs (polybrominated diphenyl ethers) or chlorinated paraffins should be added to the base material of printed circuit boards,
- halogenated polymers shall not be permissible and
- organic halogenated compounds as flame retardants shall not be permissible and may not be added to the plastic parts (RAL 2009).

The **European Ecolabel** is a voluntary scheme that was introduced in 1992. It intends to encourage companies to bring products on the marked which are more environmentally friendly. The EU Ecolable is a voluntary approach to identify products which meet specified criteria or standards.
Products and services which are awarded by the eco-label carry the flower logo, that allowing consumers - including public and private purchasers - to identify products that have less environmental impacts than similar competing products. The EU Ecolabel covers a wide range of products and services, with continuous expansion of product categories. Such product groups include cleaning appliances, paper products, textiles and also electronic equipment like personal computers, notebooks and televisions. The criteria for each product group have been identified on the basis of comprehensive life cycle studies. The normal validation period is three years. This allows a regular revision to consider technical improvements and market changes. The specified product has to fulfil several criteria, like best practice or performance criteria to receive the European Ecolabel. (EC 2011a)

The general criteria for EEE are:

- Reduced energy consumption during use and stand-by
- Limitation of substances harmful for health and the environment
- Designed for higher product durability and recyclability
- Reduced solid waste production through take-back policy
- Instructions for correct environmental use

Specific criteria for the end of life phase of TVs focus on:

- Easy dismantling and disassembling (standardized connections, easily accessible)
- Incompatible and hazardous materials to be easily separable
- If labels are required, they should be easily separable or inherent
- Recyclability of :
    - 90% (by volume) of plastics and metal materials used in chassis and housing.
    - 90% (by weight) of glass used in the cathode ray tube.
- In plastic parts:
    - No lead or cadmium or metal inlays that cannot be separated.
    - One polymer or compatible polymers.
    - Permanent marking identifying the material (except extruded plastic materials and
    - the light-guide of flat panel displays)

The reduction of solid waste is addressed through a take-back policy

- Free of charge take-back for recycling of the product and its components except items contaminated by the user.
- Consumer information on how to make use of the take-back offer.

The Commission Decision 2005/341/EC11 (EC 2005) established ecological criteria for personal computers such as

- the background lighting of the LCD monitor shall not contain more than 3 mg of mercury on average per lamp,
- plastic parts shall have no lead or cadmium intentionally added,
- plastic parts shall not contain poly-brominated biphenyl (PBB), poly-brominated diphenyl ether (PBDE) or chloroparaffin flame retardants,
- Plastic parts heavier than 25 grams shall not contain flame retardant substances or preparations that are dangerous for health or the environment according to as defined in the Dangerous Substances Directive EC (1992).

The **ENERGY STAR** program comes originally from the United States. The label focused strictly on energy consumption of products. Recently, it has grown internationally to be applicable to equipment in the EU as well. ENERGY STAR requirements are also often used as a model for the energy efficiency requirements of other programs, as seen with the Nordic Swan and Blue Angel eco-labels. For this reason, it was included in this section (Nissen, 2011).

Houe and Grabot 2009 stress, that eco-labels have only an impact on customers aware on environmental problems mainly located in developed countries. Like other standards and norms, eco-labels use a specific language, which sometimes may be difficult to interpret. In spite of the methodological help indirectly provided by the eco-label, competence on environmental issues is necessary to design a green product.

Summary
Different organizations including governments and non-profit organization have developed eco-labels. Also the addressed environmental aspects of eco-label programs vary. Finally eco-labels have become a common concept to promote products which have fewer impacts to the environment than comparable products. In addition these labels have proved as a practical solution to support purchasers by simple implementation of environmental performance aspects into their purchasing decisions.

4.4.2. Green Public Procurement

Green public procurement (GPP) means "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured." (COM (2008)) GPP is a voluntary instrument, which means that individual member states and public authorities can determine the extent to which they implement it. At EU level the European Commission set an indicative target that, by 2010, 50% of all public tendering procedures should be green, where 'green' means compliant with endorsed common core EU GPP criteria.

One barrier of GPP is that for many product and service groups, public authorities do not have access to clear and verifiable criteria which allow them to incorporate environmental considerations into their tendering while complying with the requirements of the Procurement Directives and other

[11] The ecological criteria for the product group "personal computers" have been extended until 30 June 2011.

sources of procurement law. Therefore the Commission recommended the creation of a process to set clear, verifiable, justifiable and ambitious environmental criteria for products and services, based on a life-cycle approach and scientific evidence base. A first set of common GPP criteria was established in the framework of the Training Toolkit on GPP. A second set12 of GPP criteria for eight new sectors was made available in July 2010. GPP criteria are devised into core criteria, which address the key environmental impacts of a product or a service, and comprehensive criteria, which can be applied when one wants to purchase the best environmental products available on the market (like the EU Ecolabel). Public purchasers are allowed to make use of the environmental information contained in eco-labelling schemes (EC 2011b).

The Green Public Procurement Product Sheet for Mobile Phones define the core criteria as follows

- The carrier material of printed circuit boards must not contain substances or preparations that may be harmful for health according to Directive 1999/45/EC and 67/548/CEE or Regulation (EC) No 1272/2008.
- Beryllium oxide (BeO) must not be used in electronic components

Comprehensive GPP Criteria for Mobile Phones include next to the above core criteria, that Flame retardants must comply with the same regulations mentioned above classifying substances to be harmful to the health. (EC 2010)

Also companies can purchase green components or products (green purchasing) according to the criteria set by eco-labels or public procurement policies. This facilitates to be awarded an eco-label or win a public tender.

There are manifold barriers to the implementation of GPP. A number of key challenges have been identified in the RELIEF project and European Commission survey on “Green Public Procurement in Europe 2006”. These challenges include (EC Environment (2010)):

- Green products are perceived to cost more /
- lack of political support for green products
- Lack of legal expertise in applying environmental criteria
- Lack of practical tools and information or lack of training
- The need for systematic implementation and integration into management systems.
- Lack of co-operation between authorities
- Limited established environmental criteria for products/services

4.4.3. Individual manufacturer policies

According to Chancerel (2010) the restrictions of the RoHS directive were extended to other substances through voluntary actions of manufacturers like the ‘Halogen-free policy’ of the ‘High Density Packaging User Group (HDPUG)’, an association of OEMs and components manufacturers from telecommunications and the computer industry. Table 11 presents the bans or restrictions of hazardous substances adopted by the manufacturers. A substance is banned when it is totally prohibited (concentration of zero), whereas substance restrictions imply the definition of a concentration limit under which the substance is allowed and/or of exemptions.

[12] The sets of common GPP criteria can be found here: http://ec.europa.eu/environment/gpp/first_set_en.htm and http://ec.europa.eu/environment/gpp/second_set_en.htm

The GPP Training Toolkit can be found here: http://ec.europa.eu/environment/gpp/toolkit_en.htm

Table 11. Restrictions or bans of hazardous substances carried out by the manufacturers (source: Greenpeace 2010, company reports)

	Substances restricted by RoHS					Substances that are not restricted by RoHS						
Restricted substances	**PBB PBDE**	**Lead**	**Mercury**	**Cadmium**	**Chromium VI**	**Other BFR**	**Beryllium / BeO**	**Arsenic**	**PVC**	**Antimony trioxide**	**Phtha-lates**	**Nickel[13]**
Acer	n/a	Banned	Banned	Restricted	Restricted	2011[14]	2012		2011	2012	2012[15]	Restricted
Apple	n/a	n/a[16]	By moving to LEDs[17]	n/a	n/a	2008		in LCDs	2008			
DELL	n/a	n/a	n/a	n/a	n/a	2011		Planned / partly imple-mented[18]	2011[19]		2014	
Fujitsu	n/a	n/a	n/a	n/a	n/a	2013	2012		2013		2013	
HP	n/a	Banned	Banned	n/a	n/a	2011	Banned		2011	Banned	Banned	
Lenovo	n/a	n/a	n/a	n/a	n/a	2011	Banned		2011	Banned		
LGE	n/a	n/a	n/a	Restricted	n/a	2010[20]	BeO[21]		2010[20]	2012[22]	2012[22]	
Microsoft	n/a	Restricted	Restricted	n/a	Restricted	2010					2010	

[13] on product surfaces intended to come into contact with the skin

[14] Dates indicate the year of implementation of the substance ban

[15] certain phthalates are to be phased out by 2009

[16] "n/a" means that the information was not provided

[17] June 2007: first mercury free LED display

[18] According to DELL (2011) they introduced arsenic-free display glass in laptops and display monitors in 2009. DELL is planning to introduce it across their portfolio.

[19] Ban by 2011, PVC has been restricted since 2002

[20] only mobile phones; banned from TV, monitors & PC by 2012; for all products by 2014

[21] BeO banned in mobile phones; other kinds of beryllium compounds will be banned in new products by 2012

[22] banned in new mobile phones, TVs, monitors, PCs; 2014 all household applications

	Substances restricted by RoHS					Substances that are not restricted by RoHS						
Restricted substances	**PBB PBDE**	**Lead**	**Mercury**	**Cadmium**	**Chromium VI**	**Other BFR**	**Beryllium / BeO**	**Arsenic**	**PVC**	**Antimony trioxide**	**Phtha-lates**	**Nickel[13]**
Motorola	n/a	Restricted	Restricted	Banned	Restricted	2010	Banned	Banned	2010	Banned	Banned	Restricted
Nintendo	n/a	Restricted	Restricted	Restricted	Restricted		Banned		Banned	Banned	Banned	
Nokia	Banned	Banned	Banned	Banned	n/a	Banned	2010 BeO 2004	Banned	Banned	2010	Banned	Banned
Philips	n/a	Restricted	Restricted	Restricted	Restricted	2010	2008	2008	2010	2010	2010	Restricted
Panasonic	n/a	Banned	Banned	Banned	Banned	2011	Banned		2011	Banned	Banned	
Samsung	n/a	Banned	Banned	Restricted	Banned	2010	2013	Restricted	2010	2013	2012	Restricted
Sharp	n/a	Banned	Banned	Banned	Banned	2011	Banned			2010	2010	
Sony	Banned	n/a	n/a	n/a	n/a	Banned	BeO 2008, BeCu		20 11		Planned / partly imple-mented [23]	
Sony Ericsson	Banned	Banned	Banned	Banned	Banned	Banned in newer models	2010		2007	Banned[24]	2010	Restricted
Toshiba	Banned	n/a	n/a	n/a	n/a	Banned [25]	2012	free LCD	Banned [26]	2012	2012	

[23] Sony Ericsson is phthalate free in all new products (Sony Ericsson (2010))

[24] apart from some minor applications

[25] for casing and all plastic parts weighing 10g or more

[26] excluding external cables

4.4.4. Third party assessment on toxicity and live cycle impacts

One prominent example for the assessment of electronics by a third party is the “Guide to Greener Electronics” published by Greenpeace, which ranks the 18 top manufacturers of personal computers, mobile phones, TVs and games consoles according to their policies on toxic chemicals, recycling and climate change. The toxicity is assessed by an evaluation of the company’s

- chemicals policy based on the Precautionary Principle
- support of a revision of the RoHS Directive that bans further harmful substances
- management of their supply chain, in order to ensure that suppliers do not continue to use substances that are banned or restricted
- commitment to eliminate PVC all BFRs with timeline and
- Commitment to phase out all phthalates, beryllium, including alloys and compounds and antimony/antimony compounds with timelines. (Greenpeace, 2010)

The “Guide to Greener Electronics” is only based on public available data. The primary information is compiled from the company’s corporate websites. Greenpeace aims an extended producer responsibility by a simplified benchmarking model with a good visibility for the consumer.

4.5. Experiences & Challenges

The implementation of substance restrictions in general and of the RoHS directive in particular, had manifold impacts, especially on the environment and on the activities of the electronics industry and of the recycling industry.

Four environmental and human health effects due to the implementation of the RoHS were identified by Arcadis (2008):

1. **Restricted substances avoided in the production of EEE**. According to Arcadis, the use of large amounts of lead, cadmium and hexavalent chromium for manufacturing was avoided, for instance due to modifications of the composition of TV sets, PCs and refrigerators. This implies a decrease of the demand for restricted substances and of emissions in the supply chain, and therefore of the impacts of manufacturing on environment and health.
2. **Decrease in human toxicity potential and ecotoxicity potential** of EEE through the different environmental compartments (air, fresh water, terrestrial). For cadmium and hexavalent chromium, it seems that the RoHS due impact has been the largest on the human toxicity potential via the air compartment. For lead and mercury, the impacts on the human toxicity potential via the soil and fresh water compartment are also relevant.
3. **Decrease of the waste emissions being disposed** to the environment. It is estimated that the yearly amount of waste avoided being disposed to the environment will be 89800 tons of lead, 4300 tones of cadmium, 537 tones of hexavalent chromium, 22 tones of mercury and 12600 tones of Octa-BDE (Arcadis 2008), as a consequence of the substance restrictions in the new products. However, these numbers have to be considered with caution because they:
    a. are time-dependant (there is a time delay between bringing on the market of RoHS-conform products and waste generation),
    b. depend on the recycling processes applied to treat the waste material and
    c. Do not take into account the substitution materials, which, like the restricted materials, require adequate recycling to limit the negative direct and indirect environmental impacts.
4. **Reduction of the Octa-BDE volatilization losses**. Brominated flame retardants (BFR) such as Deca-BDE and Octa-BDE tend to volatilize from products during service life [JRC 2002, 2003], which may impact the environment and the human health. The RoHS directive has a positive effect on the Octa-BDE volatilization losses.

The collection of data on the impacts of the RoHS directive is challenging, because of following facts (COM, 2008b):

- There is little information about the quantities of hazardous substances used in EEE before RoHS and it is not possible to elaborate a realistic scenario on what the current situation would have been if RoHS had never existed.
- There are uncertainties about the quantities of restricted substances contained in EEE currently placed in the market: manufacturers point out that it is very difficult to know exactly the product composition in particular when it incorporates thousands of components from a long supply chain stretching around the world.
- There are uncertainties about the quantities of EEE placed in the EU market.
- It is not always easy to determine to which extent the reduction of the hazardous substances in EEE can be attributed to RoHS or is due to other factors as well, such as technology changes (for example shift from cathode ray tube TVs to flat screen TVs), consumer preferences, or other EU legal acts.

Implementation of legal requirements

Finding practical solutions to integrate eco-innovation and environmental protection in business is a challenge, especially for small and medium-sized enterprises (SME). An ongoing project called LiMaS, standing for “Life Cycle Innovation & Management for SMEs (EuP & EEE)”, aims to help European SMEs to integrate environmental protection, life cycle thinking and eco-innovation in their business. To analyze the current situation among the implementation of legal requirements for environmental protection a survey was carried out during September 2009 and May 2010. At first sight, the WEEE is the most known, followed by the RoHS and REACh regulations. The situation regarding the rest of the requirements questioned is rather different. In all the cases more than half of the companies do not know about the requirements, meaning that in the case they were affected they still are not aware. The survey also showed that the manufacturers are looking for solutions to integrate a wide range of necessary information, i.e. benchmarks with competitors’ products, environmental legislation updates, Best-Available-Techniques in each sector, legislative requirements compliance monitoring, LCA, innovative technologies, etc. (Chancerel, 2010b) This case shows that the implementation of legal framework laws is a complex and long-term process. Numerous problems on various levels had to be solved. There are various reasons for delays in the transition process, among them an under estimation of the general task and challenges in correlation with starting too late with transition activities. It has been found that the transition process is more arduous and longer than it was estimated.

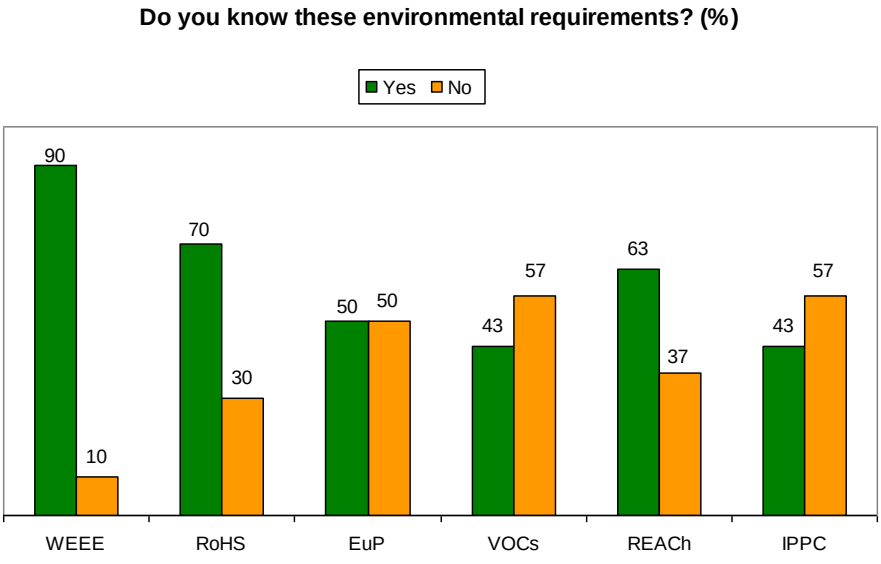

Fig. 30: Knowledge on environmental legislation (Chancerel, 2010)

According to Chancerel (2010) the environmental impacts of the RoHS do not only affect the European Union. Because a large proportion of the EEE sold in the European Union is produced outside Europe, the non-European manufacturers had to adapt their manufacturing. This possibly reduced the amounts of restricted substances emitted locally during manufacturing to the environment, for instance the composition of production waste. Moreover, some of manufacturers modified the product design and the production systems not only for the products intended to be sold in the European Union, but for their whole production, so that RoHS-conform components or products are placed in markets outside the European Union as well (Inform, 2003). This is also confirmed by the claims made by several brand name consumer electronics and IT manufacturers, as compiled by Greenpeace for their “Greener Electronics” ranking of companies. Finally, the treatment of WEEE from the European Union partly takes place outside Europe. The implementation of the RoHS directive may reduce the hazardousness of WEEE and, therefore, the hazardousness of the emissions related to recycling and disposal of WEEE (Arcadis, 2008). Unfortunately, no data are available on the international impacts of the implementation of the RoHS directive.

4.6. Conclusion: Practical substance bans for the target countries

In a result from the analyzed approaches to reduce hazardous substances use in products we developed a screening method. The screening aims to identify the most applicable approach for the target countries.

Table 12 summarize the suitability of the different approaches in target countries. A traffic light system related with criteria (complexity, costs, impact and risk) shows if the approach is practical for the target countries. Green light means that no serious problems are to be expected, a red light indicates difficulties for the respective criteria and yellow is used for medium criticality.

Table 12. A traffic light system related with criteria (complexity, costs, impact and risk) shows if the approach is suitable for the target countries.

	complexity	costs	impact	risks
law	development, implementation and control	high costs for development of new technical solutions (substitution)	high impact, but control mechanism must be implemented	low risk assuming effective control
eco-labels	depending on the required criteria	application costs (testing, application fee)	low impact, because voluntary	high risks of not being used/spread, once labelled no need to advance
green public procurement	specifications have to be developed	companies just have to comply with specs, no additional costs	high impact because of high volumes	low risk when specifications are valid
individual manufactures policies	potentially low, companies work economically	manufacturers will try to keep costs low	depends on companies and quantity of goods	depends on companies and quantity of goods
third party assessment	collection of data (reliant on manufacturers)	nearly no costs for manufacturer	willing to advance because of comparison with competitors	not all will participate
voluntary agreements	potentially low, companies work economically	RD&D investments	depends on companies and quantity of goods	voluntary agreement might not be implemented, probably no penalties

As the table illustrates, have laws and eco-labels significant risks in more than one criterion concerning the intended implementation. With three green lights the green public procurement

seems to be the most promising approach. Public institutions and organizations have a significant investment volume on office equipment. Therefore it is expected that the implementation of GPP will have high impacts for ICT equipment in the office sector. The risk that such measures will fail is relatively low. Furthermore the proposed GPP will not result into direct extended costs for the companies. The main obstacle for GPP is the development of compatible specifications and guidelines with clear and verifiable criteria which allow environmental purchase considerations. To overcome such barriers simplified criteria are required. Using existing substance ban criteria like RoHS compliance would be a first solution.

5. SUMMARY

This survey provided by the project partners has identified best practices in Europe and non European countries regarding the implementation of Integrated Solid Waste Management Systems (ISWMS) adapted to regional conditions in these countries.

Against the background of the “Regional evaluation of the situation in the target countries” (Deliverable 2.1) the lessons learnt from the best practices and to be applied in the target countries can be summarized as following:

Regional evaluation in Deliverable 2.1 has shown that the concepts of Integrated Waste Management are not widely acknowledged in the target countries, i.e. waste management is not seen as a total system from generation, through collection, treatment to reuse and recycling or disposal. Consequently, a central piece of legislation laying down the principles of waste management for a broad range of waste streams - like the waste framework directive in the EU - is missing. Moreover decrees are missing giving concrete advice on how general terms for waste management shall be implemented in detail.

The Example of the Netherlands shows that the key for their successful development of waste management was based on the cooperation between local, provincial and national government. Those three authorities reached a consensus to implement waste management programs and to comply with all agreements issued by the council, thus guaranteeing common responsibility and reliance for the planning and implementation of decisions. Furthermore the Lansink´s Ladder principle as the guiding principle for all integrated waste management activities is established in the waste legislation of the Netherlands. This waste management hierarchy represents a specific order of preference which implies that prevention is the most preferred option while landfilling of waste is the least preferred on. To implement the lansink ladder in the Dutch waste policy the following measures were taken:

- devising and adopting instruments to encourage of enforce prevention and recycling and reduce the waste going to landfill
- setting environmental and policy constraints for waste management
- creating a framework for waste management planning at national level
- spelling out the responsibilities of producers for the disposal of their products in the waste phase
- regulating imports and exports of waste

Number of instruments have been developed, both regulatory and non-regulatory, to encourage waste prevention and to raise awareness among the public with regards to waste generation. In the case of industrial waste, these instruments represent a specific section of integrated set of measures, among which are energy and water conservation. These are compiled in an implementation program developed by the Association of Provincial Authorities, the Association of Netherlands Municipalities and the Ministry of Housing, Spatial Planning and the Environment. Financial instruments, such as the landfill tax additionally promote decreasing of waste generation and discourage landfill practices.

The provenance of the waste determines the way an organizational system should be designed and the responsibilities are assigned. Wastes generated by industries or complex waste streams like Waste Electrical and Electronic Equipment can be better managed by the producer of the waste than by governmental bodies. The polluter pays principle and the Extended Producer Responsibility concept should be followed as much as possible with the government setting clear framework conditions under which the responsible bodies have to act. A clear assignment of

responsibilities among national, regional and municipal authorities, private sector organisations and individuals has proven to be a key factor of success.

Across the world, public finance for urban infrastructures and service delivery typically accrues from municipal tax revenues, user fees and government transfers. For many African municipalities, property tax is the major source. Nevertheless experience has shown that service users are prepared to pay for their waste to be removed when they agree with the service levels, when the charging system is transparent and when services are provided for locally acceptable prices.

The research results in Deliverable 2.1 identified that potential financial resources in the target countries are not raised.

- For example, there is a willingness of households and business to pay for regular waste collection services. There is a trend in Ghana, as well as in other countries in the region, towards procuring fees for waste collection from the waste generation. This can be arranged as door-to door collection or as “pay-as-you-dump”, when fees are also charge at communal collection points.
- Recycling is a source for economic value from waste which has not been well developed in the region. There is a recycling market, including informal waste buyers who go from door to door, waste pickers at collection points and disposal sites, and a largely informal, but partly formal market for recycled materials. The market is most developed for metals and e-waste, which have the highest market prices, but there are also recycling markets for plastics, paper and organic waste, primarily as compost.

Activities and strategies described above that have been part of the Swedish development include the application of the polluter pays principle:

- firstly by making waste producers, including households, pay for collection and treatment of their waste,
- secondly by differentiating fees to incorporate environmental costs and stimulate change, for example by differentiated waste collection fees designed to encourage source separation and recycling of waste
- Possibly also by producer responsibility systems.

Given the problems with funding integrated waste management activities in the target countries alternative ways to stimulate waste segregation are necessary.

Several European and Spanish regulations on specific waste streams have lead to variety of collective take-back systems. Experience in Europe has shown that collective take-back systems with active stakeholder management provide a sound basis for moving forward, both at the European and national levels, with efficient and cost-effective system for collection and recovery of a waste type. They offer the simplest, most straightforward and cost-effective approach, besides they place manufacturers in a key role as the primary managers of the recycling infrastructure through governance of the management entity. These integrated management systems are focused on post-consume waste of household packaging (plastic, glass, metal and paper/cardboard), phytosanitary packaging, medicinal packaging and unused household medicines, waste electrical and electronic equipment, batteries and accumulators, lighting systems, lamps and used tyres.

What is seen most relevant in a West African context is the process to reduce land-filling (or dumping) of waste and increase recycling and energy recovery. As the experiences in the European Members States have shown it is a long-term process to abolish land-filling of mixed MSW (e.g. more than 20 years in Sweden). Activities necessary in the target countries besides applying the polluter pays principle for funding waste-management shall comprise:

- use of information campaigns and education in schools to promote recycling and waste reduction,

- national and local waste management plans, which describe the current situation, the goals within a 5-10 year time frame, actions needed and resources required to reach these goals and
- an institution for cooperation between municipalities, which also provides links between researchers and practitioners

The collection of waste in the target countries should be optimized balancing out cost factors and convenience elements for the consumer. Separation should be promoted as far as possible at the source of the waste generation and circles for re-integration should be kept as small as possible. Biodegradable waste should be processed as far as possible in a decentralized system seeking low-cost solutions (see the examples in South Africa). Plastic waste collection should be promoted as far as possible for monotype waste only and separation should be done in an early stage in order to avoid cross-contamination by hazardous waste fractions. For hazardous and toxic waste from households special collection campaigns should be offered.

The collection system for household waste and recyclables should be built-up and operated considering settlement structures and existing door-to-door collection by waste-pickers. This will require a close collaboration with settlement organizations and the informal sector. Mechanization of the collection scheme should only start where suitability and access are assured. The selection of collection schemes for waste collection should be based upon a detailed analysis of waste types, quantities and occurrence.

When it comes to reduce the amount of hazardous substances in products besides the ban of hazardous substance by legal restrictions (e.g. in the European RoHS Directive) alternative approaches widely used to reduce the environmental impacts of products in Europe are:

- Eco-labels,
- Individual manufacturer policies,
- Voluntary industry agreements,
- Procurement policies: Green Public Procurement, Green Purchasing,
- Third party assessment on toxicity and life cycle impacts and
- Voluntary take back systems from individual producers or collection schemes from an industry association.

Applying these alternative approaches in the context of the target countries the ban of hazardous substances has significant risks due to its complexity and costs and eco-labels due to their low impact. Green public procurement seems to be the most promising approach. Public institutions and organizations have a significant investment volume on office equipment. Therefore it is expected that the implementation of GPP will have high impacts for ICT equipment in the office sector. The risk that such measures will fail is relatively low. Furthermore the proposed GPP will not result into direct extended costs for the companies. The main obstacle for GPP is the development of compatible specifications and guidelines with clear and verifiable criteria which allow environmental purchase considerations. To overcome such barriers simplified criteria are required. Using existing substance ban criteria like RoHS compliance would be a first solution.

6. REFERENCES

Ali, M., Ed. (2004). Sustainable Composting: Case studies and guidelines for developing countries. Loughborough, WEDC, Loughborough University, UK.

AUTRET Erwan, BERTHIER Francine, LUSZEZANEC Audrey, NICOLAS Florence (2005): Incineration of municipal and assimilated wastes in France: Assessment of latest energy and material recovery performances. WasteEng2005 conference N°1, Albi , FRANCE (17/05/2005).

Association for the Protection of the Environment website, http://www.ape.org.eg/, accessed: March 20, 2011.

ASHOKA website, Ashoka Fellows: Mohamed Sherif El Ghamrawy, http://www.ashoka.org/node/2997, accessed: February 4, 2011.

Agence National des Dechets website, http://www.anged.nat.tn/, accessed: March 5, 2011

CID 2008: *The Informal Sector in Waste Recycling in Egypt,* Final Report, CID/GTZ, May 2008

Arcadis (2008): Study on RoHS and WEEE Directives N° 30-CE-0095296/00-09, Final report. 06/11925/AL. European Commission DG Enterprise and Industry. Online verfügbar unter http://ec.europa.eu/environment/waste/weee/pdf/rpa_study.pdf.

BITKOM (2008): REACH und die ITK-Branche. Herausgegeben von Bundesverband Informationswirtschaft Telekommunikation und neue Medien e. V. (BITKOM). (Umwelt und Energie, 5).

Chancerel, Perrine (2010): Desk Study on worldwide impacts of Substance Restrictions of ICT Equipment. Fraunhofer IZM.

Chancerel, Perrine (2010b): Chancerel, Perrine; Schischke, Karsten; Alonso, J. Carlos; Rodrigo Julio; Cañellas, Noemi; Campo, Francisco (2010): Helping SMEs to Care for Eco-Innovation beyond Legal Compliance. Conference paper: Going Green Care Innovation. Vienna.

COM (2008): Public procurement for a better environment. COM (2008) 400 final, vom 16.7.2008. Online verfügbar unter http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0400:FIN:EN:PDF.

COM (2008b): Commission of the European Communities. Commission staff working paper accompanying the proposal for a directive of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) – impact assessment. Brussels, COM (2008) 809.

DELL (2011): Greener Materials: What's Inside Our Products — And What's Not. Online verfügbar unter http://content.dell.com/us/en/corp/d/corp-comm/earth-greener-products-materials.aspx, zuletzt aktualisiert am 2011, zuletzt geprüft am 12.04.2011.

EC (1992): Council Directive 92/32/EEC of 30 April 1992 amending for the seventh time Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances, vom 30.04.1992.

EC (2005): Commission Decission establishing ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to personal computers, vom 11 April 2005.

EC (2010): Mobile Phones. Green Public Procurement Product Sheet. Herausgegeben von European Commission DG Environment. Online verfügbar unter http://ec.europa.eu/environment/gpp/pdf/mobile_phone_GPP_product_sheet.pdf, zuletzt aktualisiert am 09.11.2010, zuletzt geprüft am 06.04.2011.

EC (2011a): Ecolabel. Herausgegeben von European Commission. Online verfügbar unter http://ec.europa.eu/environment/ecolabel/index_en.htm, zuletzt aktualisiert am 25.01.2011, zuletzt geprüft am 06.04.2011.

EC (2011b): Green public procurement. Herausgegeben von European Commission. Online verfügbar unter http://ec.europa.eu/environment/gpp/index_en.htm, zuletzt aktualisiert am 29.03.2011, zuletzt geprüft am 06.04.2011.

EC Environment (2010): Barriers to the take-up of GPP. Online verfügbar unter http://ec.europa.eu/environment/gpp/barriers_en.htm, zuletzt aktualisiert am 09.12.2010, zuletzt geprüft am 12.04.2011.

EurActiv (2010): Lawmakers seal deal on toxic substances in electronic goods. Online verfügbar unter http://www.euractiv.com/en/sustainability/lawmakers-seal-deal-toxic-substances-electronic-goods-news-499989, zuletzt aktualisiert am 25.11.2010, zuletzt geprüft am 06.04.2011.

Greenpeace (2010): Guide to Greener Electronics. (Version, 16). Online verfügbar unter http://www.greenpeace.org/international/PageFiles/24451/Guide-Greener-Electronics-11-edition.pdf.

European Commission 2011: Summaries of Europe legislation. Waste Management. [http://europa.eu/legislation_summaries/environment/waste_management/index_en.htm]. March 2011.

Eurostat statistics, Processing of urban waste in Europe and the trends in recent years, 2006

Fransen, F., van Maaren, J., Scheinberg, A., Solid Waste Management in the World's Cities, Rotterdam, 2008

Houe, Raymond; Grabot, Bernard (2009): Assessing the compliance of a product with an eco-label: From standards to constraints. Modelling and Control of Productive Systems: Concepts and Applications. In: International Journal of Production Economics, Jg. 121, H. 1, S. 21–38.

Inform (2003): INFORM, Inc. Impact of RoHS on Electronic Products Sold in the US. September 2003

IPC (28.04.2009): Material Composition Declaration for Electrotechnical Products. Joint Industry Guide. Online verfügbar unter http://www.ipc.org/4.0_Knowledge/4.1_Standards/Free/Joint-Industry-Guide-Ed2.pdf.

Michel, Hans-Jürgen; Ahto, Riita; Tamminen, Jouni (2008): Environmental Legislation Affecting Electronics Manufacturing - RoHS -REACh - Full Material Data. In: Reichl, Herbert; Nissen, Nils F.; Müller, Jutta; Deubzer, Ottmar (Hg.): Electronic Goes Green 2008+. Proceedings. Stuttgart: Fraunhofer IRB Verlag.

Körner,I, Saborit-Sánchez, I & Aguilera-Corrales, Y 2007, „Proposal for the integration of decentralized composting of the organic fraction of municipal solid waste into the waste management system of Cuba", Waste Management 28 (2008) 64–72,

Ministry of Housing, Spatial Planning and the Environment; June 2011, Factsheet

Made in Holland; Waste; October 2008

Ministry of Environment of Tunis website, Fourth Islamic Conference of Environment Ministers, 5-7 October 2010, http://www.cime-tunisie.nat.tn/index.php?option=com_content&view=article&id=54&Itemid=65&lang=en, accessed: February 25, 2011.

Michel, Hans-Jürgen; Ahto, Riita; Tamminen, Jouni (2008): Environmental Legislation Affecting Electronics Manufacturing - RoHS -REACh - Full Material Data. In: Reichl, Herbert; Nissen, Nils F.; Müller, Jutta; Deubzer, Ottmar (Hg.): Electronic Goes Green 2008+. Proceedings. Stuttgart: Fraunhofer IRB Verlag.

Nissen, Nils F. (7th 2011): EuP Preparatory Studies, Lot 26: Networked Standby Losses. Final Report Task 1, Definition. TREN/D3/91-2007/Lot 26. Fraunhofer IZM. Berlin.

Nasreya Hazardous Waste Treatment Center Website, http://www.nasreya.com, accessed: March 3, 2011.

Personal Interview: *Eng. Deif Suleiman*, Manager of Nasreya Hazardous Waste Treatment Center, Alexandria. Interviewed: March 27, 2011.

RAL (2009): Basic Criteria for Award of the Environmental Label. Computers (Workstation Computers and Portable Computers) RAL-UZ 78. Hg. v. RAL gGmbH.

Sony Ericsson (2010): Substance control. Full material declaration of our products. Online verfügbar unter http://www.sonyericsson.com/cws/corporate/company/sustainability/consciousdesign, zuletzt aktualisiert am 2010, zuletzt geprüft am 12.04.2011.

C, Eklund L., Nyström K., Zinn E., Jönsson H. 2006 Urban composting in South Africa-sustainability aspects. Proceedings ORBIT 2006 Biological Waste Management - From Local to Global. Weimar, Germany.vol 2: pp. 539-548.

UNFCCC 2006: Onyx Gas Capture and Flaring Project, CDM Project Design Document http://wbcarbonfinance.org/docs/Egypt_Onyx_PDD.pdf

UNHABITAT 2004: Best Practices Database, http://www.ucl.ac.uk/dpu-projects/drivers_urb_change/urb_environment/pdf_Planning/HABITAT_BestPractice_Sustainable_Tourism.pdf , accessed: March 25, 2011

Valorga International 2006: La valorisation optimale des dechets organiques. [http://www.valorgainternational.fr/fr/]. March 2011.

Waste Management Authority of SenterNovem

Widmer et al., (2005): Widmer R.; Oswald-Krapf H.; Sinha-Khetriwal D.; Schnellmann M.; Böni H. Global perspectives on e-scrap. Environmental Impact Assessment Review 25, 2005: 436–458

Zurbrügg, C, Drescher, S, Rytz, I, Maqsood Sinha, AH, & Enayetullah, I 2005, „Decentralized composting in Bangladesh, a win-win situation for all stakeholders", Resources, Conservation and Recycling 43 (2005) 281–292

Zurbrügg et al., (2006). Decentralised composting for low- and middle-income countries - A user's manual. SANDEC, EAWAG, Switzerland