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Potential opportunities of recycling and reuse of IT equipment

TKV Finland Oy case study

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The purpose of this final year project was to investigate the potential development of reusing and recycling technology from the point of view of in electronic equipment. TKV Finland Oy, whose head office was located in Helsinki, Finland, and whose activities are focused on sustainable redistribution of electronics, was taken as a model company.

The post-customer stage of electronic product life cycle was examined by using TKV Finland Oy as an example, and the current EU legislation on waste electrical and electronic equipment and electrical and electronic equipment waste market was studied.

The results of the final year project show positive changes in the waste electronic equipment market affected by recent legislation amendments and indicate aspects to be improved.

Keywords	Electronic waste, e-waste, WEEE, EEE, reuse, recycle

List of abbreviations

BATRRT - Best Available Treatment Recovery and Recycling Techniques

C&F - Cooling and Freezing

CFC – Chlorofluorocarbon

CFL – Compact Fluorescent Lamps

CRT - Cathode Ray Tube

EEE – Electrical and Electronic Equipment

EU – European Union

EUROSTAT - European Commission Statistical Information

FDP – Flat Display Panel

LC – Life Cycle

LHHA – Large Household Appliances

TFT - Thin Film Transistors

WEEE – Waste Electrical and Electronic Equipment

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1 Introduction

A large body of data concerning electronic waste management has been reported in recent years. Nowadays, the world market is oversaturated by electronic devices, the demand for which is growing while the usage life cycle of which is becoming shorter. As a result, it leads to an extensive amount of electronic waste being discharged to the landfills. This waste contains substances hazardous for human health and for the environment.

Therefore, this thesis focused on the potential opportunities of recycling and reusing of electronic equipment as a means of reducing environmental impact. The importance of this topic cannot be underestimated as the necessity of electronics grows day by day.

The purpose of the thesis was to investigate the potential development of reusing and recycling technology from the point of view of electronic equipment. TKV Finland Oy Company, whose head office is located in Helsinki, Finland, and whose activities are focused on sustainable redistribution of electronics, was taken as a model. The case study one of the company's projects was considered.

The objectives of the thesis was to examine the post-customer stage of product life cycle using TKV Finland Oy as an example as well as to study the current EU legislation on waste electrical and electronic equipment.

The remainder of this thesis is divided into five chapters.

Chapter 2 describes the background underlying the work, defines the main concept of electronic waste market, provides an overview of the volume of electronic waste in the world, as well as of the impact of electronic waste on the environment.

Chapter 3 presents the model used in the sustainable management of the electronic waste, namely the composition of WEEE and the recommended collection and sorting procedures. The chapter also considers the issue from three different points of views: managerial, technological and economical.

In chapter 4, reviews the post-customer stage of a product life cycle before its disposal and shows the potential opportunities for extending the electronic LC by the reusing.

In chapter 5, the governmental policy on electronic waste management is taken into consideration; the main directive is analyzed and described briefly.

Chapter 6 is the last part of the thesis, which summarizes the discussion and draws conclusion on the considered topic.

2 Theoretical Background

2.1 Introduction to the electronic waste market

The amount of electronic waste generated is growing rapidly. The content of hazardous components in electrical and electronic equipment is a major concern during the waste management phase. The strategy for waste management states that where the generation of waste cannot be avoided, it should be reused or recovered. [1]

2.2 Definition

The European Parliament directive defines electronic waste management concepts as follows:

(a) 'electrical and electronic equipment' or 'EEE' means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex IA and designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current;
(b) 'waste electrical and electronic equipment' or 'WEEE' means electrical or electronic equipment which is waste within the meaning of Article 1(a) of Directive 75/442/EEC, including all components, subassemblies and consumables which are part of the product at the time of discarding;
...
(d) 'reuse' means any operation by which WEEE or components thereof are used for the same purpose for which they were conceived, including the continued use of the equipment or components thereof which are returned to collection points, distributors, recyclers or manufacturers;
(e) 'recycling' means the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery which means the use of combustible waste as a means of generat-

ing energy through direct incineration with or without other waste but with recovery of the heat. [1, page 6]

2.3 Volume of electronic waste in EU

Electronic waste is one of the fastest growing waste streams in the world. The share of WEEE in the total amount of solid waste produced in the World is about 1- 5% and this number is increasing every year. In EU, historically, WEEE increases by 16-28% every five years, which is three times faster than average annual municipal solid waste generation. [2]

The usage period of life cycle of modern computers has decreased from 6 to 2 years over the last decade, and mobile phones become obsolete even faster, on average, in less than two years. The volume of production of household appliances is constantly increasing. This is facilitated by the rapid development of computer technology and the increasing number of computer users in the world. This occurs due to the fact that people are constantly updating their equipment and as a consequence the volume of WEEE is increasing correspondently.

In 2011 the world produced nearly 54 million tons of used electrical and electronic products. That is an average of about 20 kg for each of the 7 billion people on Earth (see Figure 2.1). [3]

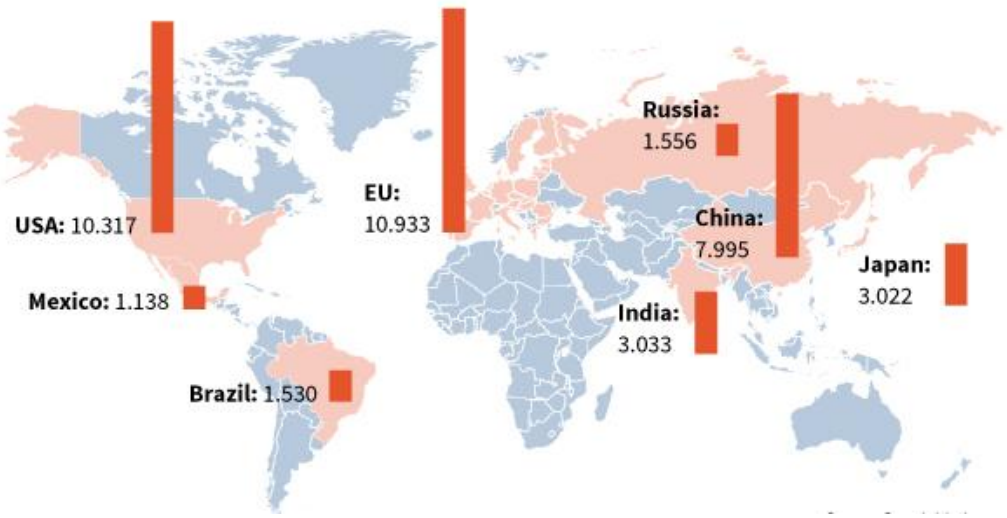

Figure 2.1. WEEE generation by country (2012 total, in millions of tons) [3].

In Europe there is a comprehensive and formal regional strategy on electronics recycling. European Directive 2012/19/EU on Waste Electrical and Electronic Equipment sets a minimum collection target of 4 kg per year per inhabitant for WEEE from households. The overall aim for the EU is to recycle at least 85 percent of electrical and electronics waste equipment by 2019. [4]

The collection rate of WEEE in the EU provided by EUROSTAT for the year 2012 is shown on Figure 2.2 below.

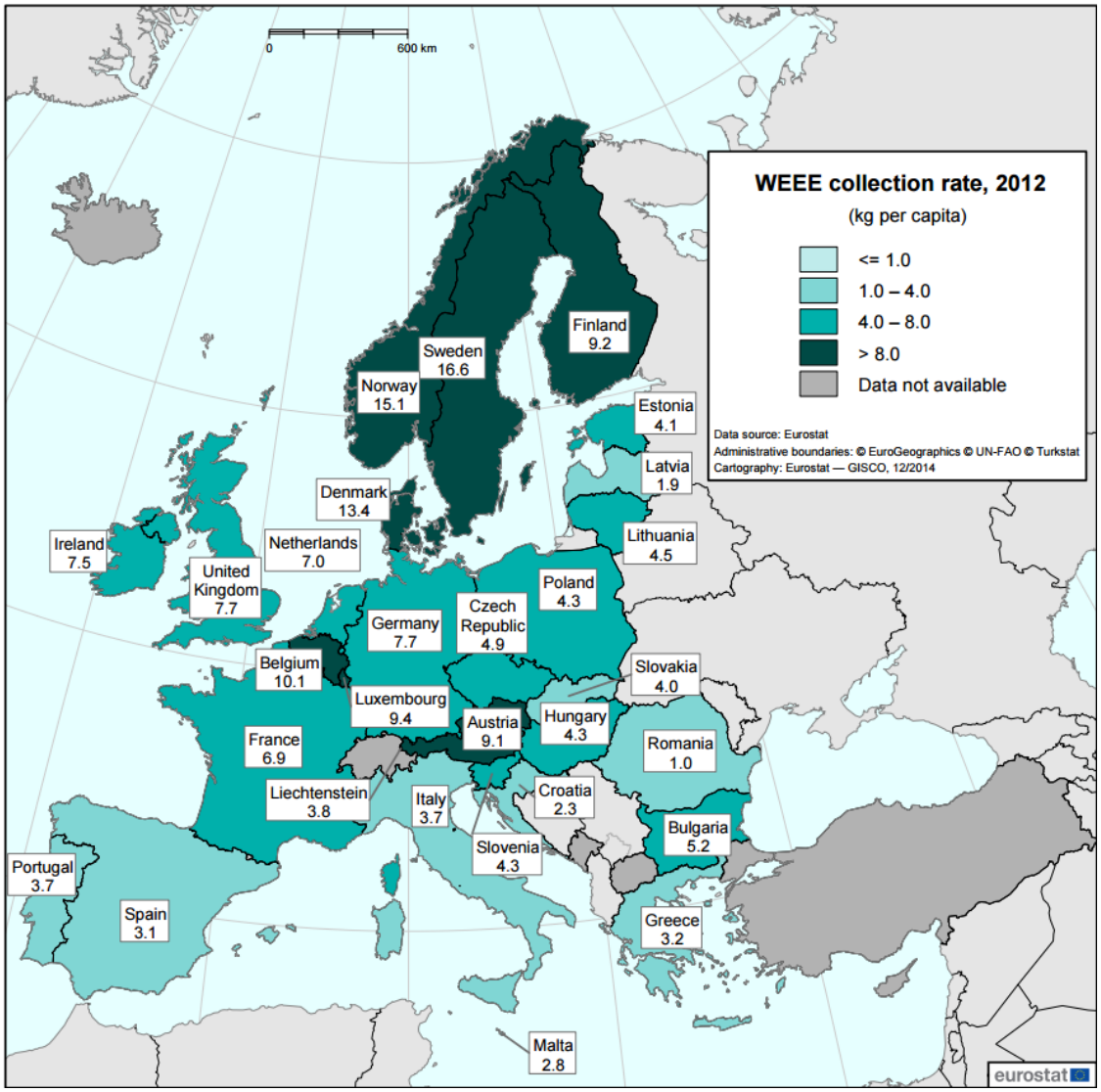

Figure 2.2. WEEE collection rate in the EU in 2012 [5].

As it can be seen from Figure 2.2, not all EU countries are able to follow the rate of 4 kg per capita. The Article 7 of the WEEE Directive allows the diminished collection rate for the following EU countries, because of their lack of the necessary infrastructure and

their low level of EEE consumption: Bulgaria, the Czech Republic, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia and Slovakia.

According to data collected by EUROSTAT, the collection rate in Finland in 2012 was 9.2 kg per capita, and from the data available in the EUROSTAT database it is known that the amount of reused and recycled WEEE in Finland in 2012 was 8.7 kg per capita. Thereby, the rate of treated WEEE in Finland in 2012 was estimated to be about 95% of the collected WEEE.

2.4 Impact of the growing volume of electronic waste on the environment

The growing volume of electronic equipment production and usage has an absolute effect on the environment. The negative environmental impact of electronic equipment arises from the globally polluting supply chain, from the increasing production of electricity needed to power the world's installed stock of computers and other electronic equipment, and from the rapid obsolescence pattern, which leads to discarded equipment. On the other hand, that equipment has a potential to generate significant environmental benefits through changes in product design and production processes, and more generally, through the more efficient use of resources. A proper management is intended to minimize the volume of WEEE being sent to landfills and promotes reusing, recycling and remanufacturing as ways to reduce the environmental impact.

The growing volume of electronic consumption may affect the environment directly and indirectly. Direct effects are caused by dumping the electronic products to the landfills, which increases the possibilities of hazardous substances leaching into the environment. Indirect effects occur due to the falling prices of EEE products, which lead to negative environmental implications arising from the increased direct consumption, use, and disposal of EEE. [6]

3 WEEE Recyclability and Its Challenges

3.1 WEEE composition

The composition of WEEE/e-waste is very diverse and differs in products across different categories. It contains more than 1000 different substances, which fall under the

categories *hazardous* and *non-hazardous*. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the WEEE followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminium and precious metals, for example, silver, gold, platinum and palladium. The presence of elements such as lead, mercury, arsenic, cadmium, selenium and hexavalent chromium and flame retardants beyond threshold quantities in WEEE/e-waste classifies the waste as hazardous waste. [7]

In order to categorize the common composition of WEEE, it has been divided into three main categories: *large household appliances, IT and telecom* and *consumer equipment*.

Each of these WEEE categories has been classified with respect to 12 most common components:

1. Radioactive substances, refractory ceramic fibers, electrolyte capacitors (over L/D 25 mm), textile and magnetron are not present in any item;
2. Plastic, circuit board and external electric cables are present in a majority of items. BFR/FR containing plastic is present in refrigerators, laptops, televisions and cellular telephones;
3. Refrigerators are unique items because of the presence of CFC/HCFC/HFC/HC, cooling, insulation, an incandescent lamp and a compressor;
4. Heating elements are found in washing machines, while thermostats are found in both refrigerators and washing machines;
5. Fluorescent lamps are found only in laptops and cellular telephones;
6. Metals and motors are found in majority of items except for refrigerators;
7. Transformers are not found in washing machines, refrigerators and cellular telephones;
8. CRT is found in personal computers and TVs, while LCD is found in PCs, TVs and cellular telephones;
9. Batteries are found in PCs, laptops and cellular telephones;
10. Concrete is found in washing machines;
11. Rubber is found in refrigerators and washing machines;
12. Wiring/electrical components are found in all the items. [7]

Combined data of 3 main categories of WEEE and 12 most common components are presented in table 3.1 below.

Table 3.1. Components in WEEE [8].

	Large Household Appliances		IT & Telecom Equipment				Consumer Equipment
	Refrigerator	Washing Machine	Personal Computer (Base & Keyboard)	Personal Computer (Monitor)	Laptop	Cellular Telephone	Television
Metal	✓	✓	✓			✓	✓
Motor	✓	✓	✓		✓		
Cooling	✓						
Plastic	✓	✓	✓	✓	✓	✓	✓
Insulation	✓						
Glass	✓	✓				✓	
CRT				✓			✓
LCD				✓	✓	✓	
Rubber	✓	✓					
Wiring / Electrical	✓	✓	✓		✓		✓
Concrete		✓					
Transformer			✓		✓		✓
Magnetron							
Textile							
Circuit Board		✓	✓	✓	✓	✓	✓
Fluorescent lamp (ineballast)					✓	✓	
Incandescent lamp	✓						
Heating element		✓					
Thermostat	✓	✓					
FR/ BFR – containing plastic	✓				✓	✓	✓
Batteries			✓		✓	✓	
CFC, HCFC, HFC, HC	✓						
External electric cables	✓	✓	✓	✓	✓		✓

✓ - present as a component

A full list of products which fall under the WEEE directive can be found in Annex I and Annex II of the European Directive 2012/19/EU of on Waste Electrical and Electronic Equipment.

The approximate recyclability of average weight of an 27kg PC and its economic value is described in Table 3.2.

Table 3.2 Recoverable quantity of elements in a PC. [8]

Elements	Content (% of total weight)	Content (kg)	Recycling efficiency (%)	Recoverable weight of element (kg)
Plastics	23	6.25	20%	1.25069408
Lead	6	1.71	5%	0.08566368
Aluminum	14	3.85	80%	3.08389248
Germanium	0.0016	0.00	0%	0
Gallium	0.0013	0.00	0%	0
Iron	20	5.57	80%	4.45453312
Tin	1	0.27	70%	0.19188512
Copper	7	1.88	90%	1.69614576
Barium	0.0315	0.01	0%	0
Nickel	0.8503	0.23	0%	0
Zinc	2	0.60	60%	0.35979072
Tanialum	0.0157	0.00	0%	0
Indium	0.0016	0.00	60%	0.00026112
Vanadium	0.0002	0.00	0%	0
Terbium	0	0.00	0%	0
Beryllium	0.0157	0.00	0%	0
Gold	0.0016	0.00	99%	0.000430848
Europium	0.0002	0.00	0%	0
Tritium	0.0157	0.00	0%	0
Ruthenium	0.0016	0.00	80%	0.00034816
Cobalt	0.0157	0.00	85%	0.00362984
Palladium	0.0003	0.00	95%	0.00007752
Manganese	0.0315	0.01	0%	0
Silver	0.0189	0.01	98%	0.005037984
Antinomy	0.0094	0.00	0%	0
Bismuth	0.0063	0.00	0%	0
Chromium	0.0063	0.00	0%	0
Cadmium	0.0094	0.00	0%	0
Selenium	0.0016	0.00	70%	0.00030464
Niobium	0.0002	0.00	0%	0
Yttrium	0.0002	0.00	0%	0
Rhodium	0	0.00	50%	0
Mercury	0.0022	0.00	0%	0
Arsenic	0.0013	0.00	0%	0
Silica	24.8803	6.77	0%	0

3.2 Managerial and Technological aspects of recycling

Due to the heterogeneous composition of the WEEE, several key issues concerning electronic waste management are identified as operational necessities for effective WEEE recycling.

Operational necessities:

1. Collection infrastructure - for waste management purposes, it is important to collect and separate different types of WEEE according to the subsequent waste treatment and recycling processes. According to the European Environment Agency (EEA), different categories of WEEE should be created (EEA, 2003):

    a) Refrigerators/freezers to enable separate treatment of CFC;
    b) TV sets, monitors to enable special treatment of circuit boards and parts containing flame retardant;
    c) Lighting equipment for mercury recovery;
    d) Large white goods. After removal of capacitor that might contain PCB the ferrous, non-ferrous and plastic fraction can be recycled directly.

2. Dismantling and separation - the important first step for reducing amounts of WEEE and emissions from WEEE treatment is to dismantle and separate electrical and electronic equipment waste. The aim is to improve the situation in which a large portion of WEEE is landfilled.

3. Improvement of treatment processes - A high percentage of WEEE is still treated in municipal waste incinerators and an increasing amount is processed in industrial facilities for recycling purposes. These facilities should be equipped with appropriate abatement technologies. [10]

Technological aspect of Recycling

As it was mentioned in section 3.1 on WEEE composition, an extensive amount of hazardous impurities can be found in electronic waste; therefore, guidance on the treatment of these substances should be considered.

Waste treatment instructions can be found in the document "Guidance on Best Available Treatment Recovery and Recycling Techniques (BATRRT) and Treatment of Waste Electrical and Electronic Equipment (WEEE)". A brief summary of the guidance given by the Department for Environment, Food and Rural Affairs, UK, can be found in Appendix II of this thesis. [10]

3.3 Economical aspect of recycling

In Figure 3.1 below a summary chart of the processing costs of WEEE treatment is presented.

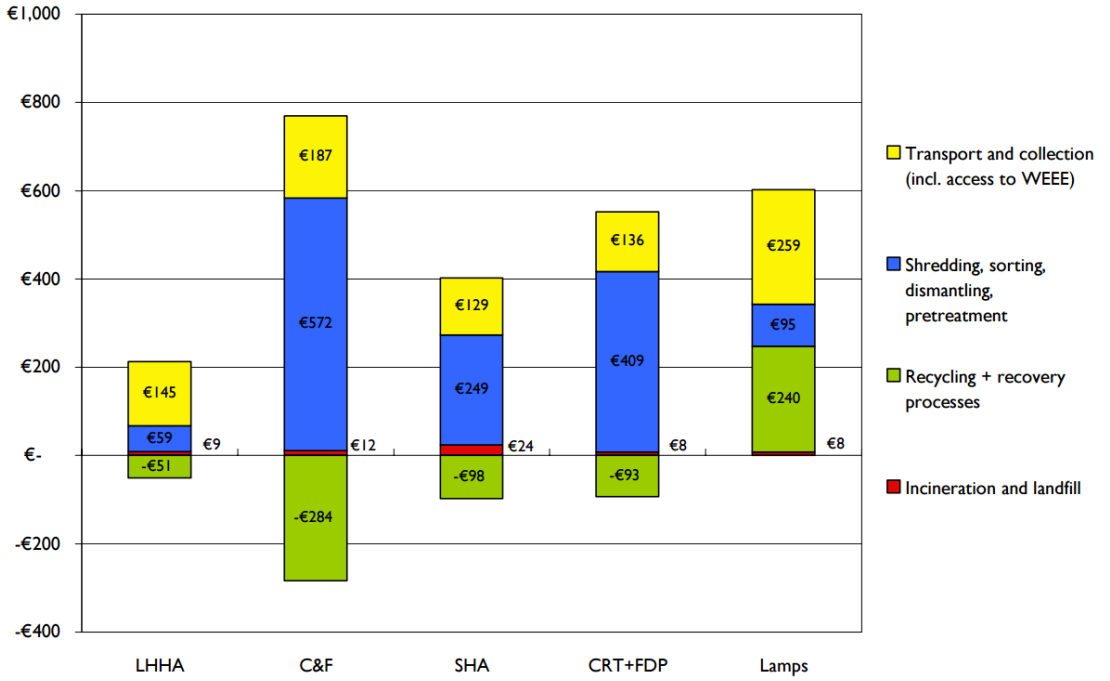

Figure 3.1. Processing costs of five main electrical components. [11]

As it is shown in the figure, the main costs in the category LHHA (large household appliances) accounted for by transportation and logistics. In the next category – C&F (cooling and freezing) - dismantling is the major concern. The treatment costs are the main expenditure in the CFC (Chlorofluorocarbon) category, as well as in the category CRT+FDP (Cathode ray tube and flat display panel). Lamp recycling is the most expensive type of recycling due to the costly mercury removal technology.

This chart was relevant to the electronic waste composition of the year 2006. Although, it is possible to predict the future of the waste composition. Nowadays, the CRT moni-

tors have almost left the WEEE market. They have been replaced by thin film transistor (TFT) monitors with compact fluorescent lamps (CFL). In consequence of this change, the recycling costs of the monitors have increased because it is expansive to remove the mercury in the CFL lamps. On the other hand, this TFT monitors will also gradually phase out. Already now LED monitors replace CFL, and in a few years LED monitors will again change the WEEE composition and affect the recycling costs. [11]

In this way, it is clear that the fast growing electronic equipment market changes the electronic waste composition, and it is essential for the producers, recycling companies and legislation to be flexible to those changes.

4 Post Customer Stage of Electronic Equipment Life Cycle

4.1 Introduction

In Finland, the WEEE directive (Valtioneuvoston asetus sähkö- ja elektroniikkalaitero-musta (852, 2004), which entered into force in 2005, transferred the responsibility for the waste management of household appliances and it equipment from the municipalities to the importers and manufacturers of household appliances. The producers and importers of electrical and electronic equipment formed three producer co-operatives, SER-Tuottajayhteisö ry (SERTY), Elker Oy ERP Finland ry and ERP Finland ry, which manage the producer responsibility obligations for collection and recycling of WEEE material on behalf of its members. [12]

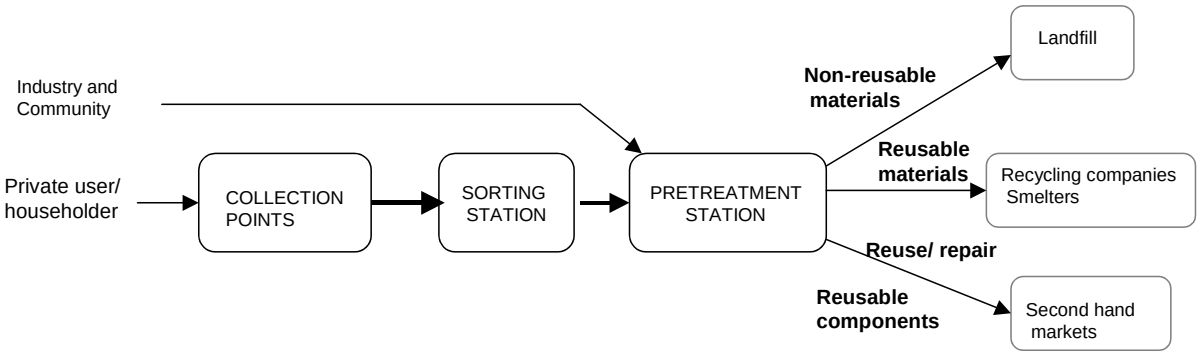

Figure 4.1. The basic stages of reverse collection of WEEE in Finland. [13]

Post-customer treatment of WEEE includes many stages. The stages are: collection, transportation, sorting, disassembly and selling reusable products. The producer co-operatives are sourcing the reverse logistics; it means that a private user can bring his used product to a collection point free of charge. In Finland there are 448 collection points [12]. However, companies are obligated to return the WEEE directly to sorting stations and pay for its recycling. The basic stages of reverse collection of WEEE in Finland are presented in Figure 4.1. [13]

4.2 TKV Finland Oy

TKV Finland Oy continues the business with used IT equipment inherited from the former company International Computer Brokers ICB-Finland which operated from 1981 to 1994.

TKV Finland inherited a number lot of good practices that originate from the 80s. It cooperates in depth with another domestic computer broker company Cimos Oy. These two companies are the domestic market leaders for used computer equipment. TKV Finland Oy both buys and sells used equipment on the B-to-B market domestically and the company is also a strong player on the international market with big exports/imports operations worldwide. It is specialized on doing business with Russia. From an environmental perspective the used IT-market represents sustainability as re-using computer equipment saves a large amount of natural resources and energy.

TKV Finland Oy provides the following services:

Information security

Information security is essential in the company. All products that contain information are secure cleaned. All possible information that remains after use is removed from all data storage produces. TKV Finland Oy provides a full report about the data erased from hard drives and other storage devices.

Purchase Service

TKV Finland Oy buys used computer equipment such as laptops, desktops, monitors, servers, network equipment, printers and disk storage systems if further use is possible. However, the devices should not be older than 5 years.

Sales Service

TKV Finland Oy sells used equipment for export and also to the domestic Finnish market. Its specialists can give recommendations based on the goals and objectives. Furthermore, company provides computers and laptops for rent for exhibitions and seminars.

Upgrade Service

TKV Finland Oy provides an upgrade service. It can upgrade and recycle old equipment. The company recycles everything that is impossible to sell through companies which are professionals in waste disposal.

4.3 Post-customer stage of electronics life cycle

TKV Finland Oy is mainly a used IT equipment broker, which is a connection element in a chain of first user and re-user of equipment. The company receives equipment either from second hand markets or directly from private users or companies.

The schematic process of the company is shown on the flow chart below (see Figure 4.2).

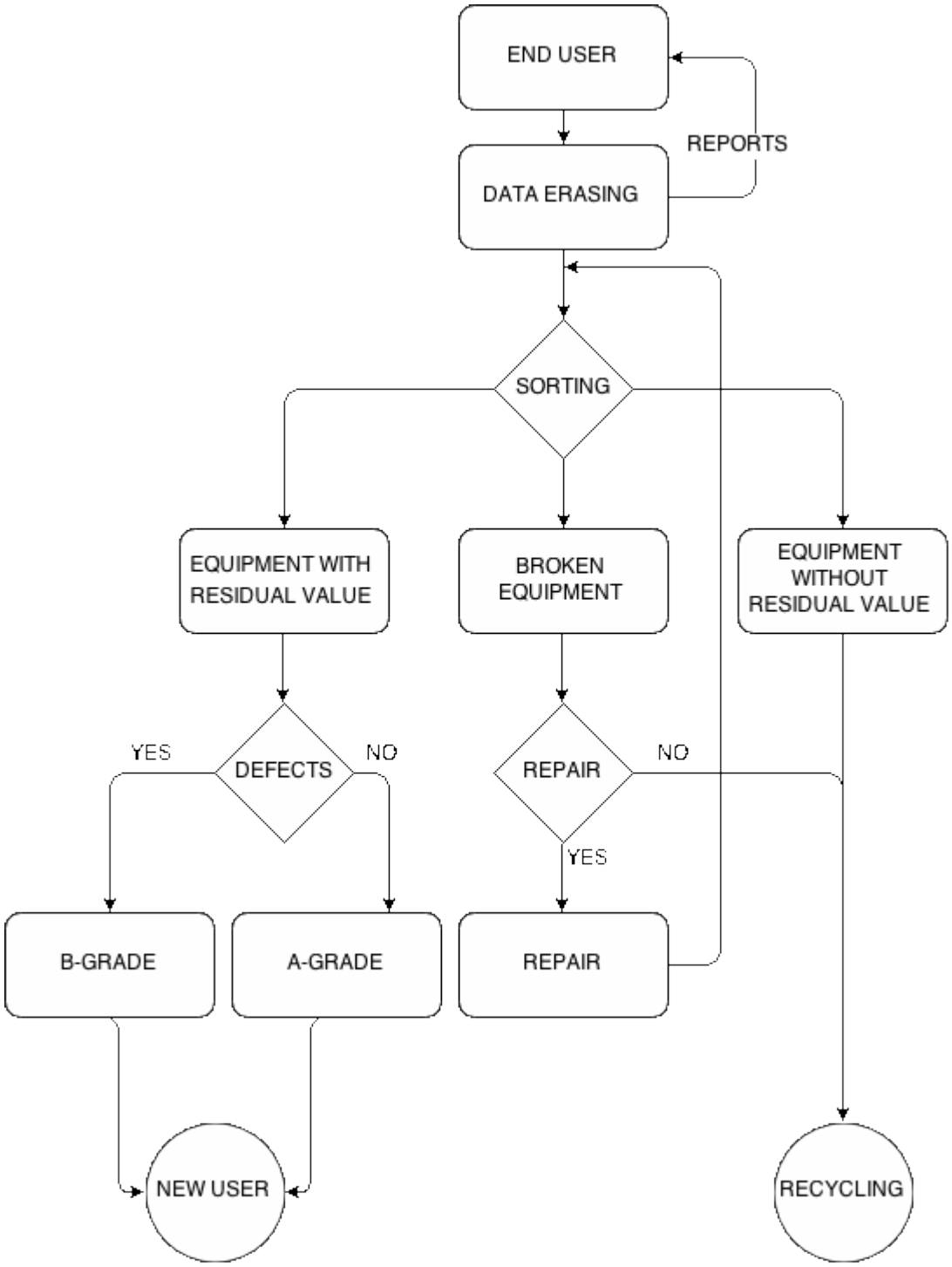

Figure 4.2. Post customer treatment flow chart of EEE in TKV Finland Oy.

According to the presented flow chart, before the used EEE again comes to the market, it has to proceed with several important steps as follows:

1. First, the equipment has to be received from the end users. Typically, it is done by post or other courier services. Also TKV Finland Oy could offer delivery services within Uusimaa region, Finland;
2. Secondly, end user information in all the equipment has to be erased to comply with the security agreement. TKV Finland Oy uses the most advanced data erasure technology, which at the end provides to the former user a comprehensive report to prove successful data erasure;
3. Thirdly, after successful data erasure, the equipment goes to the quality control department and sorting by the grades with respect to its condition:

    - A-Grade - equipment that has a residual value on a market and has no visible or other defects;
    - B-Grade is fully working equipment with visible cosmetic defects, although, the residual value of such an equipment is decreasing;
    - Scrap-Grade is broken equipment.

4. Fourthly, the equipment has to be listed and the product data base has to be updated;

5. Finally, the equipment are sold to the costumers; 6 months of after the sale service is provided for every re-used item.

The broken equipment has to be fixed if it is reasonable; after that the grade is assigned according to requirements mentioned above. If it is impossible to fix the equipment or if it is unreasonable, then the grade s*crap* is assigned and the EEE is forwarded to the treatment and recycling facilities company.

4.4 Recycling of WEEE

The fastest way to treat WEEE is shredding the material and then separating of small fractions. Typical shredding facilities consist of several basic elements such as a shredder, a cyclone, a magnet and eddy current separators, and hand picking.

The schematic process of typical recycling facility is shown in Figure 4.3 below.

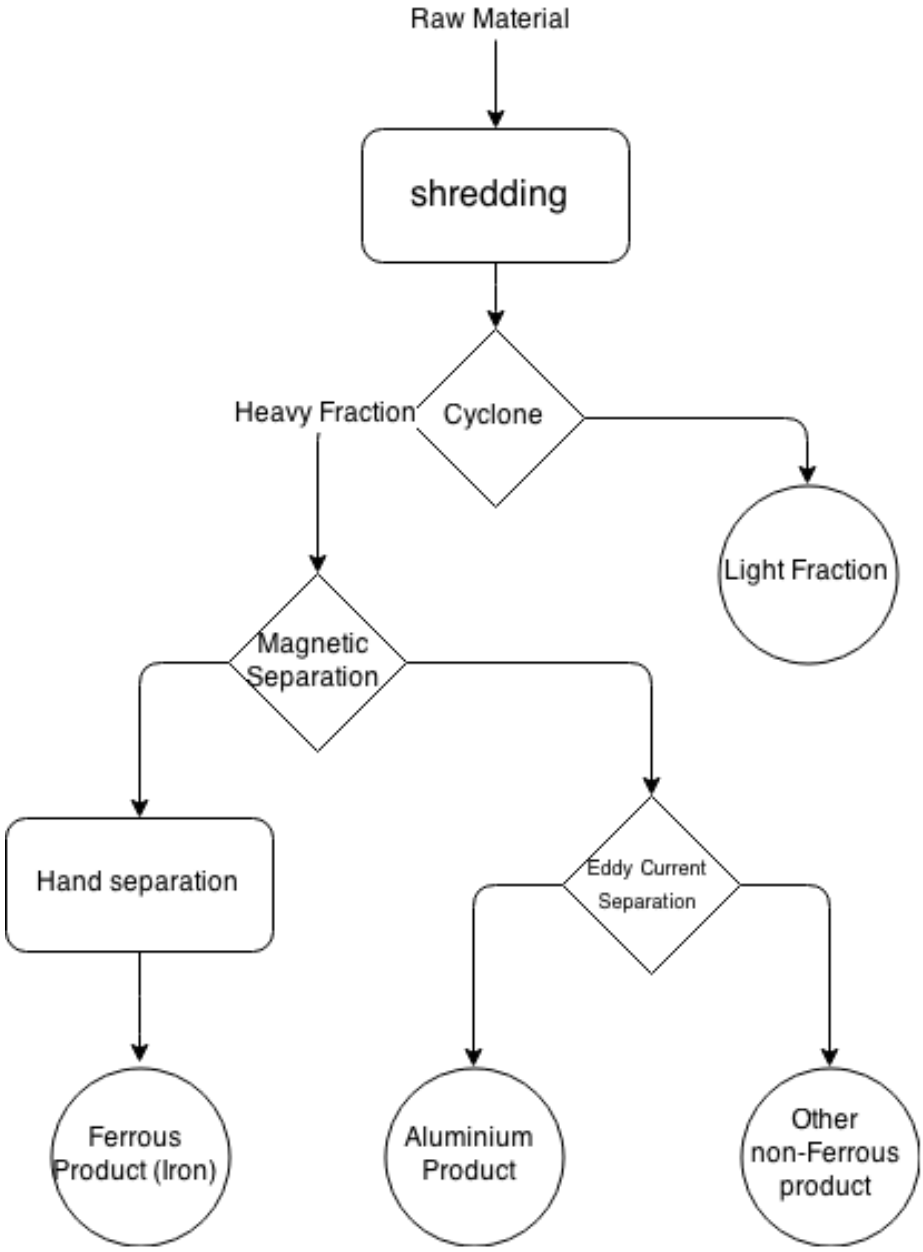

Figure 4.3. Schematic process of typical recycling facility.

At the treatment facilities, before shredding, all products that contain hazardous substances, such as lead and cadmium, are removed manually.

After presorting, the material is fed into the shredder, where the scrap is fragmentized.

After shredding, the light fraction is separated from the heavy fraction (mainly ferrous and non-ferrous metals) by making use of a big cyclone.

After the cyclone, the ferrous fraction is separated from the heavy fraction by a magnet separator. The ferrous fraction then is sent for hand sorting where copper wires, cloths, some plastics, and other non-metals are separated from the ferrous stream, and the ferrous fraction is prepared for sale to the metallurgical industry.

The non-magnetic part of heavy fraction is processed further by using an eddy current separator to separate aluminum and its alloys from the non-magnetic fraction. This aluminum fraction is sold to customers.

The remaining part after the eddy current separator mainly consists of different metals (especially precious metals and their alloys) as well as different kinds of plastics. This part and the light fraction from the cyclone separator are sold to precious metals recovery facility.

5 Governmental Policy

5.1 WEEE regulated documentation

The European Community directive 2012/19/EU on waste electrical and electronic equipment is the latest recast of the law accepted by the European parliament on 27 January 2003.

5.2 Producer responsibility

The producer responsibility principle was defined at Knut Sanders' at al. final report on the producer responsibility principle of WEEE directive.

> 'The Producer Responsibility Principle as a policy principle can be summarised as "concept that manufacturers and importers of products bear a degree of responsibility for the environmental impacts of their products throughout the products' life-cycles, including upstream impacts inherent in the selection of materials for the products, impacts from manufacturers' production process itself, and downstream impacts form the use and disposal of the products.' [14, page 1]

5.3 WEEE collection requirements

The directive on waste electrical and electronic equipment regulates the product design and encourages cooperation between producers and recyclers in order to facilitate re-use, dismantling and recovery of WEEE, its components and materials.

According to the directive, the European Member States should organize a proper collection of WEEE and minimise the disposal of WEEE in the form of unsorted municipal waste. Member States shall ensure the availability and accessibility of the necessary collection facilities and allowing final holders and distributors to return such waste at least free of charge, as well as distributors provide for the collection, at retail shops.
Member States shall ensure that the collection and transport of separately collected WEEE is carried out in a way which allows optimal conditions for preparing for re-use, recycling and the confinement of hazardous substances. [15]

The directive regulates the appropriate labeling of the products placed on the market with a special symbol, preferably with accordance to European standard EN 50419. All the electronic equipment produced after 13 August 2005 shall be labeled with a symbol. Indicating symbol separate collection for EEE with a crossed-out wheeled bin shown in Figure 5.1 below. The symbol must be printed visibly, legibly and indelibly. [13]

Figure 5.1. Symbol for the marking of EEE. [15]

5.4 Information for users

According to Article 14 of the present WEEE directive, the member states are responsible for informing the EEE users of private households on “the requirement not to dis-

pose of WEEE as unsorted municipal waste and to collect such WEEE separately" and of the available ways of collecting WEEE at the appropriate collection point. In addition, the users should be informed of the role of reusing and recycling the equipment and the potential effects of hazardous substances present in the EEE on the human health and the environment. [15]

6 Discussion and Conclusion

The treatment of WEEE is a topical issue in the EU and globally. As it was mentioned previously in this thesis, the WEEE directive has changed the marked of electronic equipment. From the year 2005, the directive has prohibited the disposal of electronic and electrical equipment together with municipal waste in Europe. At the same time the responsibility for the collection, recycling and treatment of WEEE has been shifted to manufacturers. Because of this, the comprehensive products return systems were created and the reverse logistic system was improved. Moreover, all WEEE produced in the EU remain at the EU borders, which have advantages such as: treatment in accordance with advanced recycling techniques and creation of new work places.

However, despite of positive changes caused by WEEE directive, there are still aspects to be improved. As it was mentioned in chapter 3.2 of this thesis, there is still inclusion of electrical equipment in municipal waste stream. It is essential to raise consumer awareness of the options available to them for the disposal of WEEE in an environmentally friendly and responsible manner.

Moreover, quite often the used, unwanted equipment are delayed from reaching the sorting station for few years due to inconsiderable attitude of the end user and consequently it has no value for reuse. Also wrong handling and damage in transportation reduce the value for further reusing.

Furthermore, as chapter 2.3 shows, the life cycle of modern computers has decreased from 6 to 2 years [3]. Producers are not interested in manufacturing electronic products that last long; they design their products irreparable and enforce consumers to buy a new device instead of fixing the old one. It would be more practical for the electronic market to find a legislative way to oblige the producers to manufacture the products that last longer; such a tool could prove effective in prolonging the lifespan of a product and effecting reuse, respectively.

As this thesis has shown, there are considerable socio-economic and environmental benefits in reuse and recycling activities. Together with legislation, changing consumer attitude and producer responsibility, there would be a positive effect on the WEEE market in the future. As the Euro Commission recently stated, “we must move away from a wasteful economy towards one based on durability and reparability of products which is likely to create job opportunities throughout the product lifecycle in terms of, maintenance, repair, upgrade, and reuse.”[16]

References

1. The European Parliament and Council. Directive 2002/96/EC of the European Parlament and of the Council on waste-electrical and electronic equipment (WEEE). [Internet]. EUR-Lex. [Cited date: January 2003]. Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2002L0096:20080321:EN:PDF
2. Francis O. Adeola. Hazardous Wastes, Industrial Disasters, and Environmental Health Risks: Local and Global Environmental Struggles. Palgrave Macmillan, USA; 2011.
3. Ross Toro, Tracking the World's E-Waste (Infographic), [Internet]. Livescience. [Cited date: December 2013]. Available from: http://www.livescience.com/41966-tracking-world-e-waste.html
4. JIMLYNCH. Snapshot of Worldwide Electronics Recycling, [Internet]. [Cited date: 2013]. Available from: http://ifixit.org/blog/4662/snapshot-of-worldwide-electronics-recycling-2013/
5. European Commission, EUROSTAT WEEE collection data, [Internet]. Accessed on March, 2015. Available from: http://ec.europa.eu/eurostat/documents/342366/351758/weee-collection.pdf
6. Kuehr R., Williams E. Computers and environment. Understanding and Managing their Impacts. Kluwer Academic Publichers, 2003.
7. Rakesh Johri, E-Waste: Implication, regulations, and management in India and current global best practices. TERI Press, The Energy and Resources Institute, India, 2008.
8. DEFRA, WEEE & Hazardous Waste. Department of Environment and rural affairs, [Internet]. Accessed on March, 2015. Available from: http://archive.defra.gov.uk/environment/waste/producer/electrical/documents/weee-hazwaste.pdf
9. Recycling of Waste Electronic and Electrical Equipment (WEEE). Climate Tech, a clean technology platform, [Internet]. Accessed on March, 2015. Available from: http://www.climatetechwiki.org/node/5472
10. DEFRA, Guidance on Best Available Treatment Recovery and Recycling Techniques (BATRRT) and treatment of Waste Electrical and Electronic Equipment (WEEE). Department of Environment and rural affairs, [Internet]. Accessed on March, 2015. Available from:

http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/environment/waste/producer/electrical/documents/weee-batrrt-guidance.pdf

11. Huisman Jaco et al., 2008. Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE). [Internet]. Germany: United Nations University; [Cited date: August, 2007]. Available from: http://ec.europa.eu/environment/waste/weee/pdf/final_rep_unu.pdf
12. Locations of WEEE collection points in Finland. Service provided by local municipal waste management company, [Internet]. Accessed on April, 2015. Available from: http://www.kierratys.info/
13. Kari Poikela, Ulla Lehtinen. Modelling and developing a WEEE collection network in the Oulu region in Finland. Developing Social Entrepreneurship in the Field of Recycling, [Internet]. Published date: August, 2008. Accessed on April, 2015. Available from: https://scholar.google.fi/scholar?q=Modelling+and+developing+a+WEEE+collection+network+in+the+Oulu+region+in+Finland&hl=en&as_sdt=0&as_vis=1&oi=scholart&sa=X&ei=ym0pVb_aC8ivsQG3k4K4BA&ved=0CCcQgQMwAA
14. Knut Sander et al., The Producer Responsibility Principle of the WEEE Directive. [Internet]. United Nations University; [Cited date: August, 2007]. Available from: http://ec.europa.eu/environment/waste/weee/pdf/final_rep_okopol.pdf
15. The European Parliament and Council. Directive 2012/16/EU of the European Parlament and of the Council on waste-electrical and electronic equipment (WEEE). [Internet]. EUR-Lex. [Cited date: July 2012]. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0019
16. Commission staff working document. Exploiting the employment potential of green growth, [Internet]. Accessed on April, 2015. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012SC0092

Appendices

Appendix 1. DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2012 on waste electrical and electronic equipment (WEEE)

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0019

ANNEX I

Categories of EEE covered by this Directive during the transitional period as provided for in Article 2(1)(a)

1. Large household appliances

2. Small household appliances

3. IT and telecommunications equipment

4. Consumer equipment and photovoltaic panels

5. Lighting equipment

6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)

7. Toys, leisure and sports equipment

8. Medical devices (with the exception of all implanted and infected products)

9. Monitoring and control instruments

10. Automatic dispensers

ANNEX II

Indicative list of EEE which falls within the categories of Annex I

1. LARGE HOUSEHOLD APPLIANCES

Large cooling appliances
Refrigerators
Freezers
Other large appliances used for refrigeration, conservation and storage of food
Washing machines
Clothes dryers
Dish washing machines
Cookers
Electric stoves
Electric hot plates
Microwaves

Other large appliances used for cooking and other processing of food
Electric heating appliances
Electric radiators
Other large appliances for heating rooms, beds, seating furniture
Electric fans
Air conditioner appliances
Other fanning, exhaust ventilation and conditioning equipment

2. SMALL HOUSEHOLD APPLIANCES

Vacuum cleaners
Carpet sweepers
Other appliances for cleaning
Appliances used for sewing, knitting, weaving and other processing for textiles
Irons and other appliances for ironing, mangling and other care of clothing
Toasters
Fryers
Grinders, coffee machines and equipment for opening or sealing containers or packages
Electric knives
Appliances for hair cutting, hair drying, tooth brushing, shaving, massage and other body care appliances
Clocks, watches and equipment for the purpose of measuring, indicating or registering time
Scales

3. IT AND TELECOMMUNICATIONS EQUIPMENT

Centralised data processing:
Mainframes
Minicomputers
Printer units
Personal computing:
Personal computers (CPU, mouse, screen and keyboard included)
Laptop computers (CPU, mouse, screen and keyboard included)
Notebook computers
Notepad computers
Printers
Copying equipment
Electrical and electronic typewriters
Pocket and desk calculators and other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means
User terminals and systems
Facsimile machine (fax)
Telex
Telephones
Pay telephones
Cordless telephones
Cellular telephones
Answering systems and other products or equipment of transmitting sound, images or other information by telecommunications

4. CONSUMER EQUIPMENT AND PHOTOVOLTAIC PANELS

Radio sets
Television sets
Video cameras
Video recorders
Hi-fi recorders
Audio amplifiers
Musical instruments and other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications
Photovoltaic panels

5. LIGHTING EQUIPMENT

Luminaires for fluorescent lamps with the exception of luminaires in households

Straight fluorescent lamps

Compact fluorescent lamps

High intensity discharge lamps, including pressure sodium lamps and metal halide lamps

Low pressure sodium lamps

Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs

6. ELECTRICAL AND ELECTRONIC TOOLS (WITH THE EXCEPTION OF LARGE-SCALE STATIONARY INDUSTRIAL TOOLS)

Drills
Saws
Sewing machines
Equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials
Tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses
Tools for welding, soldering or similar use
Equipment for spraying, spreading, dispersing or other treatment of liquid or gaseous substances by other means
Tools for mowing or other gardening activities

7. TOYS, LEISURE AND SPORTS EQUIPMENT

Electric trains or car racing sets
Hand-held video game consoles
Video games
Computers for biking, diving, running, rowing, etc.
Sports equipment with electric or electronic components
Coin slot machines

8. MEDICAL DEVICES (WITH THE EXCEPTION OF ALL IMPLANTED AND INFECTED PRODUCTS)

Radiotherapy equipment
Cardiology equipment
Dialysis equipment
Pulmonary ventilators
Nuclear medicine equipment
Laboratory equipment for in vitro diagnosis
Analysers
Freezers
Fertilization tests
Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability

9. MONITORING AND CONTROL INSTRUMENTS

Smoke detector
Heating regulators
Thermostats
Measuring, weighing or adjusting appliances for household or as laboratory equipment
Other monitoring and control instruments used in industrial installations (e.g. in control panels)

10. AUTOMATIC DISPENSERS

Automatic dispensers for hot drinks
Automatic dispensers for hot or cold bottles or cans
Automatic dispensers for solid products
Automatic dispensers for money
All appliances which deliver automatically all kinds of products

Appendix 2. A brief summary of Guidance on Best Available Treatment Recovery and Recycling Techniques (BATRRT) and treatment of Waste Electrical and Electronic Equipment (WEEE)

http://www.hse.gov.uk/waste/waste-electrical.htm

Fluids - these are typically found in heating and cooling appliances, such as fridges and freezers (coolant circuit) and oil-filled radiators. The WEEE Directive requires the removal of all fluids from WEEE. Fluids must be safely removed prior to crushing or shredding operations. Cooling appliances containing refrigerants (fridges and freezers) – most refrigerators reaching the waste stream are between 10 and 15 years old and are therefore likely to contain Ozone Depleting Substances (ODS) (e.g. CFCs and HCFCs). Units manufactured after 1994 are unlikely to contain CFCs.

Fridges and freezers identified as containing ammonia must have their ammonia extracted and transferred to a suitable container pending disposal. As well as presenting a fire and explosion risk, ammonia is potentially hazardous to both the environment and human health.

Capacitors containing polychlorinated biphenyls (PCBs)

Historically PCBs were used extensively in electrical equipment such as capacitors and transformers. However, their use in open applications was widely banned in 1972 and they have not been used in the manufacture of new equipment since 1986. Plants that had been installed prior to 1986 were allowed to continue until the end of their working life. Thus it should be assumed that capacitors manufactured before 1976 contain PCBs. However, unless an appliance is more that 20 years old the chance that it contains capacitors containing PCBs is very remote. All uses of PCBs were to be phased out by the year 2000.

Mercury containing components such as switches or back-lighting

Mercury is used in fluorescent lamps, medical equipment, data transmission, telecommunications and mobile phones. Its use in electrical and electronic equipment has declined significantly in recent years and its use is banned (save certain exempt uses) from 2006. Apart from batteries, most other mercury containing items are likely to be

found on a circuit board. Thus removing the circuit board would result in removal of most mercury containing competent such as switches.

Increasing numbers of non-CRT flat panel screens (such as liquid crystal display (LCD), laptop and desk top monitors and plasma screens) are entering the waste stream and requiring specialist treatment. The current main option for treatment is manual disassembly to remove the mercury containing backlights for specialist treatment and the separation of the remaining material streams. This has high labour costs and potential health and safety implications.

Toner cartridges, liquid and paste, as well as color toner

Commonly found in printers, fax machines and photocopiers. These should be removed whole and intact so as to prevent the dispersal of toner and then stored in suitable labeled containers.

Asbestos waste and components which contain asbestos

Asbestos has been used in older appliances such as electric coffee pots, toasters and irons. Asbestos was also a component of some electric heaters and other items that benefited from the heat resistant properties of the material. Modern appliances are not permitted to contain asbestos; however, operators of treatment facilities need to be vigilant for items which might contain asbestos. Appliances that are over 20 years old might contain asbestos and therefore should be examined carefully and treated accordingly.

Lead and other substances including phosphorous pentachloride in CRTs

Lead and other substances hazardous to health such as phosphorous pentacholoride can be liberated during the processing of the glass to remove the fluorescent coating.

Components containing refractory ceramic fibers (RCFs)

Mainly used in furnace/heater/kiln linings. Reparable RCFs are classified as category 2 carcinogen. Although RCFs may be used in both domestic appliances and building

heating appliances, the insulation material used in domestic electrical appliances are more likely to contain components based on mineral wools rather than RCFs. Appliances which might contain RCFs must be examined to determine if they contain RCFs and appropriate controls put in place before they are removed.