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MASTERARBEIT

Understanding the Barriers to Recycling of Waste Electrical and Electronic Equipment

von

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Vorwort

Diese Arbeit beinhaltet eine Analyse des britischen und österreichischen Elektro- und Elektronikaltgeräte Recyclingsystems, vergleicht deren jeweilige Vor- und Nachteile und deckt die Hindernisse für das Erreichen höherer Recyclingraten auf.

Sie wurde im Zuge des Double-Degree Programmes der Universität für Bodenkultur in Wien und der Cranfield University in Großbritannien im Zeitraum von Mai 2011 bis Dezember 2011 verfasst. Der Großteil dieser Arbeit entstand während eines einjährigen Studienaufenthalts in Großbritannien, in Österreich wurden anschließend Teile erweitert und ergänzt.

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Zusammenfassung

Elektroaltgeräte gehören zu den am schnellsten wachsenden Abfallströmen in Europa. Dieser Abfallstrom enthält sowohl toxische Substanzen als auch wertvolle Rohstoffe, und kann somit nicht wie herkömmliche Abfälle aus Haushalten behandelt und entsorgt werden. Im Jahr 2003 wurde von der EU die „Richtlinie des Europäischen Parlaments und des Rates über Elektro- und Elektronikaltgeräte (EAG)“ (WEEE – Richtlinie) in Kraft gesetzt. Diese soll den Schutz der Umwelt und der Ressourcen durch u. a. vorgegebene Sammel- und Verwertungsquoten sicherstellen. Mit der Einführung der Produzentenverantwortlichkeit sollen diese die wirtschaftliche und physische Verantwortung dafür übernehmen und zu Öko-Design ermutigt werden. Bei der Umsetzung dieser Richtlinie in nationales Recht ergaben sich aber in vielen Fällen Schwierigkeiten und Probleme technischer, administrativer und ökonomischer Natur. Diese führten z.B. zu hohen Verwaltungskosten bei zu geringer Effizienz, zu Wettbewerbsverzerrungen durch unnötigen Verwaltungsaufwand und zu unzureichendem Schutz der Umwelt, da derzeit weniger als 50% der in Verkehr gebrachten Elektro- und Elektronikgeräte gemäß der Richtlinien registriert und behandelt werden. Auf Grund dessen wird die Richtlinie seit 2008 überarbeitet. Die nun von der Kommission vorgeschlagene Novelle soll einerseits höhere Sammel- und Verwertungsquoten vorgeben aber auch sicherstellen, dass Behördliche Hürden und Kosten so gering wie möglich gehalten und Wettbewerbsverzerrungen vermieden werden.

Im Zuge dieser Arbeit wurden die Recyclingsysteme für Elektroaltgeräte in Großbritannien und Österreich gegenübergestellt. Dabei wurden die rechtlichen Grundlagen, die Umsetzung der EU- Richtlinien, die Sammel- Verwertungs- und Entsorgungssysteme, sowie die Märkte für Sekundärrohstoffe in den beiden Ländern analysiert und verglichen. Ziel der Arbeit war es, Probleme und Hemmnisse der beiden Systeme zu identifizieren und Empfehlungen und Vorschläge zu erarbeiten, um diese Barrieren zu überwinden. Weiters wurde am Beispiel Österreich untersucht, welche neuen Herausforderungen die von der Kommission vorgeschlagene Novelle der EU-WEEE Richtlinie (WEEE Recast) und die höheren Sammelquoten für Abfallverbände, Wirtschaft sowie Sammel- und Verwertungssysteme darstellt.

Im Jahr 2009 betrug die österreichische pro Kopf Sammelquote 9,3 kg, die britische 7,3 kg. Dieser Mengenunterschied kann einerseits auf bereits vor der EU-Richtlinie existierende EAG Rechtsvorschriften in Österreich zurückgeführt werden, beruht andererseits auch auf sozioökonomische Faktoren wie Einstellung und Motivation zu Recycling, sowie auf das politische Bekenntnis zum Umweltschutz. Während bei der Umsetzung der EU WEEE Richtlinie in nationales Recht in Österreich hauptsächlich das ordnungsrechtliche Instrument gewählt wurde, setzte Großbritannien mehr auf marktwirtschaftliche Anreize. Diese unterschiedlichen Ansätze lassen sich in zum Beispiel auf Bezirks- und Gemeindeebene deutlich erkennen: Während diese in Österreich gesetzlich verpflichtet sind EAG zu sammeln, geschieht dieses in Großbritannien auf rein freiwilliger Basis über ökonomische Anreize. Auch betreffend der Sammel- und

Verwertungssysteme ist dieser Unterschied sichtbar: während in Österreich nur 5 Sammel- und Verwertungssysteme für EAG vom Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft genehmigt sind, müssen sich in Großbritannien über 40 auf einem konkurrierenden Markt positionieren. Das führt auf einem zunehmenden Preisdruck auf Kosten von niedrigeren Entsorgungs- und Verwertungsstandards. Andererseits beschweren sich in Österreich Hersteller über zu hohe Lizenzgebühren. Ein optimales System müsste die Vorteile von regulativen und marktwirtschaftlichen Instrumenten in sich vereinen.

Unabhängig von den nationalen Besonderheiten konnten Recycling-Barrieren bei EAG entlang des gesamten Produktlebenszyklus identifiziert werden, und zwar unter Anderem

- In der Produktions-Phase, in der nicht berücksichtigtes recyclingorientiertes Design (Design for Recycling) in späteren Folgen zu ineffizienter Rückgewinnung von Rohmaterialien und damit verbundenen erhöhten Kosten führt.
- Bei der Altgerätesammlung, wo geringes Bewusstsein und Wissen in der Bevölkerung zu einem unausgeschöpften Sammelpotential führen.
- In der Verwertungs-Phase, in der oft die Anwendung von nicht geeigneten Recycling-Technologien zu Verlusten von ökonomisch verwertbaren Materialien führt.

Lösungsansätze zur Verbesserung der Recyclingraten wären somit unter anderem gezielte Bewusstseinsbildung in der Bevölkerung, die Anwendung der am besten geeigneten Recycling-Technologien in Hinblick auf die unterschiedlichen Materialzusammensetzungen der Produkte sowie ein gesamter, integrierter Produktlebenszyklus - Ansatz anstatt des jetzigen, in dem Herstellung und Recycling als zwei getrennte Industrien angesehen werden.

Abstract

Waste electrical and electronic equipment (WEEE) is one of the fastest growing waste streams in Europe. As it contains both valuable material and hazardous substances, this waste stream needs to be treated appropriately. Consequently, the European Union introduced the WEEE directive in 2003. However, the directive showed dissimilarities and difficulties in the transposition of the directive into national law in each member states. For example technical, legal and administrative problems, lead to unexpected costs and market distortion. Therefore the directive is currently in a process of change as in December 2008 the EU Commission has proposed to revise the directive (WEEE Recast). This revision includes higher collection, recycling and recovery targets as well as a reduction of administrative burdens and costs.

This project investigates on the recycling of WEEE in the United Kingdom and Austria and its associated barriers. The aim was to identify and understand these barriers by analysing and comparing the WEEE recycling systems in the two countries considered. A critical analysis of how the EU directive has been implemented in both countries as well as an analysis of the differences in the collection and treatment systems and the WEEE market has been carried out. Furthermore a case study has been undertaken to find out on how the Austrian waste management associations, compliance schemes and the Austrian economy are facing the new challenges of the WEEE Recast.

The 2009 per capita collection rate was 9,3 kg for Austria and 7,3 kg for the UK. Several reasons could be found to explain this difference. Firstly, as Austria is a much smaller country, which already had WEEE regulations in place before the implementation of the directive, it did not encounter as many difficulties as in the UK. Secondly, there are reasons of economic and political nature. While in the UK a more market-based approach has been chosen, the directive has been implemented in Austria with a more regulative approach. Therefore municipalities in Austria are obliged to collect WEEE, whereas in the UK local authorities collect WEEE on a voluntarily basis. However, in both countries municipal collection points are the most important collection systems for WEEE. In Austria only four producer compliance schemes (PCS) for WEEE are authorized by the government, whereas in the UK more than 40 are competing on the market. Consequently, PCS offer their services at lower prices, which leads to lower standards of recycling. On the other hand, producers in Austria complain about prices being too high. Although a more regulated market shows to have fewer barriers in WEEE recycling; the optimal case would be the combination of both, a market based and a regulative approach.

Further barriers to recycling can be found along each stage of the product life cycle in both case studies:

- in the production stage, where the absence of recycling oriented design leads to recycling inefficiency

- in the collection stage, where missing knowledge and awareness on the consumers' part leads to inefficient collection procedures
- in the treatment stage, where non-appropriate technologies lead to environmental contamination and valuable material loss.

Barriers have also been found regarding legislation and the market. A mass-based target, for instance, leads to a focus mainly on heavy items. Too high costs may make recycling economically unattractive. In order to overcome these barriers, a balanced system between penalties and incentives has to be found, good public communications have to be applied and the best available technologies have to be provided. Last but not least, to ensure efficient recycling a whole product life-cycle management approach is of crucial importance.

Keywords:

Waste Electrical and Electronic Equipment (WEEE), Recycling, Barriers, EU-WEEE Directive, Austria, United Kingdom

Abbreviation

AATF	Approved Authorised Treatment Facility
AE	Approved Exporter
ATF	Authorised Treatment Facility
CA	Civic Amenity Site
DCF	Designated Collection Facility
DCS	Distributer Compliance Scheme
EA	Environment Agency
EAG	Elektro- und Elektronikaltgeräte
EAK	Elektroaltgeräte Koordinationsstelle
EEE	Electrical and Electronic Equipment
EoL	End of Life
EuP	Energy using Products
ERP	European Recycling Platform
HWRC	Household Waste Recycling Centre
LA	Local Authority
LAVU	Landes-Abfallverwertungsunternehmen
MA	Magistrats Abteilung

MRF	Material Recovery Facility
MS	Member State
PCS	Producer Compliance Scheme
WEEE	Waste Electrical and Electronic Equipment
WKO	Wirtschaftskammer Österreich (Austrian Federal Economic Chamber)
WRAP	Waste and Resources Action Programme

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1 Introduction

The rate of electronic and electrical equipment products (EEE) consumed in the developed world is growing rapidly. New technologies and innovations are introduced to the market within short time intervals leading to shorter life cycles of the products. As a result the volume of waste of electronic and electrical equipments (WEEE) is growing three times faster than the average waste stream in the European Union (European Commission, 2006; Rahimifard, et al., 2009). According to the European Commission (2006) the amount of WEEE produced per EU citizen is approximately 17 to 20 kg per year and is estimated to increase annually between 2.5% and 2.7% (Huisman, 2008).

The European Union has introduced the directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE directive) together with the directive 2002/95/EC on the Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS directive) in February 2003. The main aim of these directives is to protect both human health and the environment as well as to ensure resource recovery by enforced collection and recycling of WEEE. The WEEE directive initiated changes in the EU WEEE management where further emphasis towards recycling and recovering is given. The concept of introducing the producer responsibility implies that they are responsible for the products from the design stage until the End-of-Life stage. Consequently the introduction of the WEEE directive implicated a new approach for e-waste recycling in Europe. This approach involves many different stakeholders (e.g. producers, importers, consumers, local authorities, municipalities, governments or private waste management companies) leading the system to be complicated and branched. Hence, there are still many barriers to achieving a functioning and closed recycling loop for e-waste. The present study aims to identify and understand these barriers by analysing and comparing the WEEE recycling systems in the United Kingdom and Austria. The objectives of this study are:

- Comparative analysis of WEEE arisings, collection and treatment in the UK and in Austria.
- Analysis of the implementation of the EU directives in the two case studies
- Analysis of the WEEE market and specific material streams in these two countries.
- Identification of associated barriers to WEEE recycling along the product life cycle.
- A case study analysis on how the Austrian waste management associations, compliance schemes and the Austrian economy are facing the new challenges of the WEEE Recast.
- Provide recommendations on solutions to overcome barriers to recycling.

1.1 Composition of WEEE

The composition of WEEE can be characterized as a highly heterogeneous mix of materials including precious metals and hazardous components. Modern EEE products consist of up to 60 different elements in materials varying from precious resources to hazardous components (Chancerel et. al. 2009).

In general the composition of WEEE can be classified into five different categories including (i) ferrous metals, (ii) non-ferrous metals, (iii) glass, (iv) plastics and (v) other materials. Ferrous metals, especially iron and steel, are the most common materials found in WEEE accounting for almost 50% of the total weight of WEEE. Plastics are the second largest component accounting for approximately 21%. Non-ferrous metals are an important consideration when dealing with WEEE, although they only represent 13% of the total weight. For example aluminium (Al), copper (Cu) and Tin (Sn) are metals with a high value as secondary raw material and account for almost 5% of the total non-ferrous metals (Huisman et al., 2008; Ongondo, 2009). Yet, the material composition across each WEEE category varies notable. For example whereas large household appliances consist out of a large proportion of metals, small

household appliances have a much higher proportion of plastics and display and screens are by far the largest sources of glass. The average composition of the three most common WEEE categories is shown in table 1.

Gold (Au), silver (Ag) and platinum-group metals are among the precious metals found in WEEE but also rare trace metals such as selenium (Se), tellurium (Te), bismuth (Bi) and antimony (Sb) which are found in a very small quantity in this waste stream (Chancerel et al., 2009). The highest concentration of valuable metals is found in printed circuit boards (PCB), which are the main components of office, information and communication equipment as well as entertainment and consumer electronics (EMPA, 2009; Chancerel et al., 2009). According to Huisman el al. (2008) a ton of PCB in a radio set contains 520 g of Ag and 68 g Au and in a ton of DVD players PCBs 700 g Ag and 100 g Au can be found.

Material	Large household appliances (%)	Small household appliances (%)	ICT and consumer electronics (%)
Ferrous metal	43	29	36
Aluminium	14	9,3	5
Copper	12	17	4
Lead	1,6	0,57	0,29
Cadmium	0,0014	0,0068	0,018
Mercury	0,000038	0,000018	0,00007
Gold	0,00000067	0,00000061	0,00024
Silver	0,0000077	0,000007	0,0012
Palladium	0,0000003	0,00000024	0,00006
Indium	0	0	0,0005
Brominated plastics	0,29	0,75	18
Plastics	19	37	12
Lead glass	0	0	19
Glass	0,017	0,16	0,3
Other	10	6,9	5,7
Total	100	100	100

Table 1: Average material composition of three WEEE categories (EMPA, 2009)

Hazardous substances found in EEE products are heavy metals such as mercury (Hg), lead (Pb), cadmium (Cd), chromium (Cr), brominated flame-retardants, liquid crystals and toxic hydrocarbons such as polychlorinated biphenyls (PCB), polyvinyl chloride (PVC) or polybrominated biphenyls (PBB). They are found in printed circuit boards, flame retarded plastics, capacitors, batteries, liquid crystal, displays mercury switches, cathode ray tubes and resistors. Although they are only found in a very small proportion in these products, these substances have the potential to cause serious damage to human health and environment even at low concentration (Salhofer and Tesar, 2011; Wilkonson et al., 2001). Heavy metals, for example, can be carcinogenic

and damage the mental and central nervous system, they can be very persistent and tend to accumulate in the soil representing a long-term hazard (ATSDR, 2010). Toxic hydrocarbons can be carcinogenic and cause haematological effects. Further they produce neurological impairment and regarding the environment they behave very mobile in the soil environment representing a high potential risk for groundwater (ATSDR, 2004). Therefore the application of waste management strategies for conventional municipal solid waste like landfill or thermal treatment is not suitable for this waste stream.

Table 2 provides some example of hazardous substances in WEEE and its occurrences.

Hazardous Substance	Occurrence
Halogenated compounds:	
PCB (polychlorinated biphenyls)	Capacitors, Transformers
TBBA (tetrabromo-bisphenol-A)	Fire retardants for plastics (thermoplastic components, cable insulation)
PBB (polybrominated biphenyls)	TBBA is presently the most widely used flame retardant in printed wiring boards and casings.
PBDE (polybrominated diphenyl ethers)	
Chlorofluorocarbon (CFC)	Cooling unit, Insulation foam
PVC (polyvinyl chloride)	Cable insulation
Heavy metals and other metals:	
- Arsenic	Small quantities in the form of gallium arsenide within light emitting diodes
- Barium	Getters in CRT
- Beryllium	Power supply boxes which contain silicon controlled rectifiers and x-ray lenses
- Cadmium	Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying-machines (printer drums)
- Chromium VI	Data tapes, floppy-disks

- Lead	CRT screens, batteries, printed wiring boards
- Lithium	Li-batteries
- Mercury	Fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches
- Nickel	Rechargeable NiCd-batteries or NiMH-batteries, electron gun in CRT
- Rare Earth elements (Yttrium, Europium)	Fluorescent layer (CRT-screen)
- Selenium	Older photocopying-machines (photo drums)
- Zinc sulphide	Interior of CRT screens, mixed with rare earth metals

Table 2: Hazardous Substances in WEEE (EMPA, 2009)

1.2 EU legislation

Beside the WEEE and the RoHS directives, other important European pieces of legislations to be considered in WEEE management are the Energy using Products Directive (EuP Directive 2005/32/EC) and the Regulation on the Supervision and Control of Shipments of Waste (EC Nr 259/93).

1.2.1 EU WEEE directive

The EU WEEE directive (2002/96/EC) was adopted in January 2003 and came into force in August 2005. Its main purpose was to harmonize the management of an ever increasing EEE waste stream in the EU, to reduce the amount of WEEE disposed on landfill and to improve reuse, recycling and recovery rates (Cahill et al., 2010). The main objectives of the directive are:

Separate collection of household WEEE

The directive seeks to minimize the amount of WEEE disposed of in unsorted municipal solid waste by requiring the member states to set up a separate

collection for household WEEE. Therefore final holders should be able to return obsolete EEE products free of charge. This can be done either through a municipal take-back system, through the distributor when purchasing a new product on a one-to-one basis or through the producer who is allowed to set up its individual collection system or join a collective collection scheme (European Commission, 2011).

Extended Producer Responsibility and Product design

According to the EU directive a producer as defined in Article (3) is any person who:

- Manufactures and sells electrical and electronic equipment.
- Resells under his own brand equipment produced by others.
- Imports or exports EEE on a professional basis into a member state, Norway, Iceland or Liechtenstein.

The producer responsibility requires manufacturers and importers to take responsibility of their EEE placed on the market until their End-of-life (EoL) stage in terms of collection, transportation, disposal and treatment (financially and/or physically) (Yoshido et al. 2010; Defra 2010). Further it seeks to improve the environmental performance of the product along the whole life cycle (Turner and Callaghan, 2007; Wright and Elcock, 2006).

Producers are liable for the cost of collection and processing of WEEE regarding all household equipment set on the market after 13 August 2005, and responsible to set up a system for separate WEEE collection. This can be done by joining a compliance scheme or individually. Additionally they are obliged to share the cost of compliance for all “historic household WEEE” put on the market before August 2005. However, this does not apply to non-household WEEE. For these products, producers will only be liable for the cost of treatment for equipment placed on the market after 13 August 2005 but not for historic non-household WEEE, where the responsibly lies in the hands of the end user (European Union, 2010; Turner and Callaghan, 2007).

WEEE categories

The directive covers the 10 following WEEE categories (a detailed list of products which fall under the directive and its recovery, recycling and reuse targets set in the directive are shown in Appendix A1 and A2):

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools
7. Toys, leisure and sports equipment
8. Medical devices
9. Monitoring and control instruments
10. Automatic dispensers

Further obligations

The EEE for household use must have the **information on the product** that it should not be disposed of together with mixed household waste. They must be marked with a symbol of a crossed out wheeled bin and give technical information regarding treatment and reuse. For the **treatment, recovery and recycling** of WEEE the best available techniques must be applied (European Union 2010; Turner and Callaghan, 2007).

Producers in each MS have **to register and report** their quantities and categories of EEE put on the market, collected and recycled since there are different **reuse** and **recovery targets for each category.** For a non-conform reporting each MS has to set effective and appropriate penalties (European Union, 2010).

1.2.2 WEEE Recast

The EU WEEE directive is currently in a process of change as in December 2008 the EU Commission has proposed to revise the directive. Ever since the directive is going through revisions and readings. The reasons for this revision are dissimilarities and difficulties in the transposition of the directive into national law in every MS. For example technical, legal and administrative problems, lead to unexpected costs, market distortion and free riding. Furthermore continuing environmental harm is still observed all over Europe as well as a low level of innovation in WEEE collection and treatment. Consequently the Commission aims to develop a better regulatory framework, which should improve environmental performance as well as reduce administrative costs and burdens. It should improve the effectiveness when transferred into national legislation by ensuring harmonized actions as well as coherency with newer policies and legislation. (European Commission, 2011; European Commission 2008). The key issues of the amendment are (letsrecycle, 2011f):

Categorisation and Scope: The current 10 categories should be merged together to 5 (temperature exchange equipment; lighting; monitors; any other large equipment; any other small equipment) on an “open scope” basis. Consequently more products will be added in the list of “to be excluded”.

Mandatory Collection Targets: The European Commission proposed to set a weight based mandatory collection target of 45% of the equipment set on the market three years after the new directive will come into force and to raise it to a target of 65% of electrical and electronic equipment placed on the market in each MS over the two previous years not longer than after seven years after the directive came into force. On the other hand, the European Parliament proposed in February 2011 to set an 85% collection target based on all WEEE generated by 2016.

Mandatory Recycling/Recovery and Reuse Targets: The current weight based recovery and recycling target of each category should be increased by

5% each. Furthermore the new targets should also cover the re-use of whole appliances and the medical devices.

Definitions: The definition of “producer” “distributor” and “importer” should not leave as much space for national interpretation anymore. Therefore the Commission proposes to define these key concepts on an EU basis. Furthermore producer registration and reporting should be harmonized by making the national registers interoperable.

Illegal Shipment: a new annex should tackle illegal export of WEEE by introducing minimum requirements of shipment of WEEE/functional EEE to non-OECD countries.

1.2.3 RoHS Directive

The RoHS Directive 2002/95/EC is strongly linked to the WEEE directive. Its aim is to reduce the environmental impact of EEE products placed on the market after July 1, 2006 by prohibiting the use of Pb, Hg, Cd, hexavalent Cr, certain brominated flame-retardants like PBB or PDE. The categories to which the RoHs directive is applicable are the categories 1-7 and 10 from the WEEE directive (Ongondo et al., 2010; Wright and Elcock, 2006; European Union, 2010).

1.2.4 EuP Directive

The EuP Directive 2005/32/EC, introduced in 2007, is a directive concerning eco-design of energy-using products in order to reduce their environmental impact. It provides principles, conditions and criteria energy-using products must fulfil to be placed on the EU market. The aim of this directive is to improve energy efficiency of these products and reduce their environmental impact. (European Union, 2008a; Ongondo et al., 2010)

1.2.5 Basel Convention and shipment of WEEE

The EC Nr 259/93 Regulation on the Supervision and Control of Shipments of Waste represents the decisions on transboundary movement of waste from the Basel Convention and other OECD agreements. It aims to prevent the shipment of hazardous waste, and therefore also WEEE containing hazardous substances, to a non-OECD country (Hawking and Shaw, 2004).

1.3 Recycling of e-waste

Definitions as in the EU Directive 2002/96/EC on waste electrical and electronic equipment, Article 3

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*

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 generating energy through direct incineration with or without other waste but with recovery of the heat*

Recovery *means ... the use of materials principally as a fuel or other means to generate energy,...the recycling/ reclamation of metals and or metal compounds without endangering human health and without the use of processes or methods likely to harm the environment*

The process of e-waste recycling consists of collection, pre-processing and end-processing (Figure 1; Chancerel et al., 2009; Schluep et al. 2009).

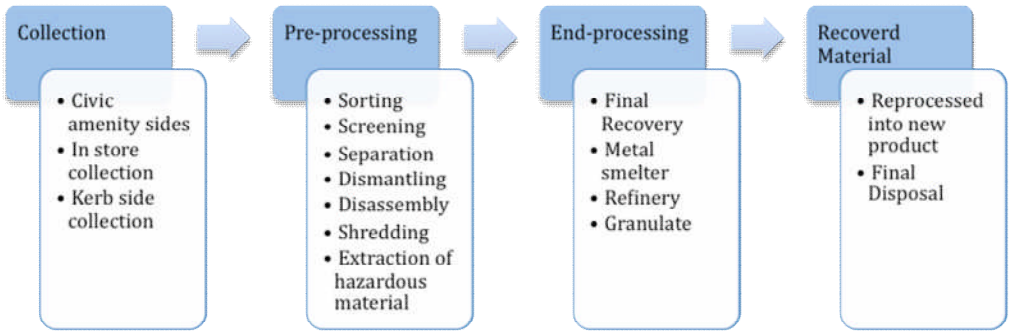

Figure 1: WEEE recycling chain

The efficiency of each stage depends on the efficiency of the previous stage. Consequently a high recycling rate is determined by cooperation between the single steps within the whole recycling chain (Chancerel et al. 2009; Schluep et al. 2009).

The **collection** rate depends on many different factors including social, economic and socio-demographic factors and the collection system itself. However this first step is essential since the amount of material being recycled is highly dependent on the efficiency of the system (Chancerel et al. 2009; Schluep et al., 2009).

The **pre-processing** stage is of crucial importance since it prepares the material for final refining and/or upgrading. It involves the use of mechanical or physical separation. Pre-processing can be sorting, screening, separation (e.g. magnetic separation, eddy current separation or density based separation), manual or mechanical dismantling, disassembly or shredding. This step further involves the removal of hazardous substances or valuable components (Chancerel et al., 2009; Schluep et al., 2009).

End processing is the final step and the refining of the secondary raw material. Particular emphasis is given to non-ferrous metals such as Al, Cu, Au, Ag, ferrous metals such as iron and steel and recyclable plastic and glass. Examples for this process are the recovery of ferrous metals at steel plants, the

recovery of Al at aluminium smelters or the recovery of Cu, Pb or precious metals at integral smelters (Schluep et al. 2009; EMPA, 2009).

1.4 WEEE quantities in Europe

Huisman et al. (2008) estimated the WEEE arising in the 27 European Union (MS) to be between 8.3 and 9.1 million tonnes per year. The number of EEE products placed on the market is estimated to be about 15% higher than the actual WEEE arising, including non-household equipment. The average per capita amount of WEEE collected in 2008 in the EU 27 was 5,3 kg (European Commission, 2008). However, the collection rate varies strongly across Europe (Figure 2). Whereas some MS have reached the target by far, for some others, especially some new EU27 MS, achieving this target is still a challenge.

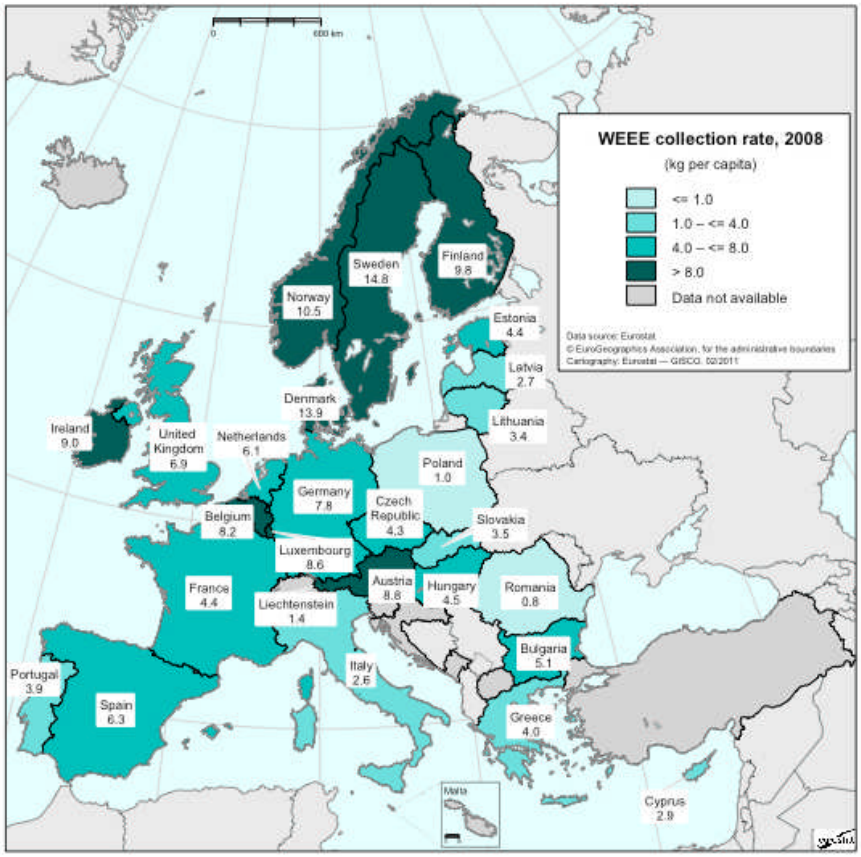

Figure 2: WEEE collection rates across Europe (European Commission, 2008)

One reason for this disparity is the fact that some MS had already implemented national WEEE regulations before the implementation of the WEEE directive (Khetriwal, 2009). Austria for example had been operating a system for consumers to recycle cooling appliance since 1993 and Belgium had an established producer compliance scheme since 2001. On the other hand Bulgaria and UK framed their national WEEE legislation only in 2006 (Cahill et al., 2011).

Although the total EU WEEE collection rate of 68% (European Union, 2008b) seems to be very high, only 26% of the WEEE is reported as being properly treated in terms of recycling and recovery (European Union, 2008b). The typical composition of WEEE collected across Europe consists by almost half of large

household appliances (49%), followed by consumer equipment (21%), IT and telecommunications equipment (16%), small household appliances (7%), electrical and electronic tools (4%) and categories 7, 8, 9 and 10 contribute each less than 1%. This proportion shows that the return of appliances lighter than 1 kg is very rare while heavier appliances are very likely to be collected (Huisman et al., 2008). New targets in the directives amendment should even this proportion and work towards an increase in the overall European WEEE recycling rate.

2 Methodology

In this project a qualitative case study analysis of household WEEE recycling in the UK and in Austria was carried out. This analysis includes the implementation of the EU directives; WEEE quantities, collection and treatment; the consumer attitudes towards recycling, as well as a basic market analysis and material flow in the two countries. Based on this comparison and analysis generic barriers to WEEE recycling were identified. The barriers were categorized in 1) Legislation and Policies 2) Production 3) Collection 4) Processing and Treatment 5) Economy and Market

The information was obtained through a thorough literature research, an analysis of existing project and research work done in this field as well as an analysis of the legislation and its implementation in the EU, Austria and the UK. Furthermore surveys were conducted via email and telephone interview with WEEE process plant operators, local authorities and municipalities, waste management associations and compliance schemes in the UK and in Austria. These interviews helped to provide the understanding of the systems whereby questions regarding the following issues were asked:

To local authorities and waste management association:

- Provided collection services
- Residents acceptance and use of the collection infrastructure
- Exhaustion of collection potential
- WEEE routes after collection

To WEEE plant operators:

- Sources of input material
- Material flow after treatment
- Amount of input material regarding capacity

To compliance schemes:

- Relation to local authorities
- Weaknesses of the proposed amendment of the WEEE directive by the European Commission (This question has only been asked to the Austrian compliance schemes)

The main data used in this project are data published by the UK Environment Agency (*http://www.environment-agency.gov.uk/business/topics/waste/111016.aspx*), the Austrian Elektroaltgeräte Koordinationsstelle (*http://www.eak-austria.at*), the Austrian WEEE treatment status report 2008 (*www.umweltbundesamt.at/fileadmin/site/publikationen/REP0199.pdf)* and the European Commission (Eurostat) (*http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/data/wastestreams/weee*). However, the different data representation and the different national categorisations lead to difficulties giving accurate comparisons.

For chapter 3.8 (WEEE Recast - New Challenges: Case study Austria) a survey has been carried out among the Austrian waste management associations. The aim of this survey was, to indentify if the waste management associations see the proposed collection targets by the European Commission for the amendment of the WEEE directive as realistic and what measures have been set and/or will be set in order to achieve them. From 30 sent out questionnaires via e-mail, 13 have been answered and returned. The actual questionnaire is shown Appendix A3.

3 System Analysis

In order to identify the barriers to WEEE recycling, a comparative analysis of the recycling systems in the UK and Austria has been undertaken. Since many stakeholders and actors are involved, these systems are relatively complicated and branched. Therefore the analysis and the WEEE life cycle represented in this paper are limited to general aspects. Due to the limitations of this project the analysis did not include the stages prior to the consumer's choice of discarding the equipment.

Although in terms of WEEE management the UK is being placed in the better half of the EU, it is still lagging behind some other European countries, among them Austria. One reason for this is that Austria had already a well-established infrastructure before the implementation of the directive as well as well-established companies dealing with secondary raw material. However, according to the Environment Agency (2011a) the amount of WEEE being collected and recycled in the UK is increasing every year decreasing the gap between the UK and the leading WEEE recycling countries in Europe. Yet, the amount being collected, treated and recovered still has more potential in both countries.

Figure 3 and 4 show the possible path of WEEE recycling in the two countries. The paths are divided in official and unofficial routes. "Official WEEE" is registered and reported. The percentages given in these figures have been extrapolated from the British Environment Agency and the Austrian Elektroaltgeräte Koordinationsstelle data.

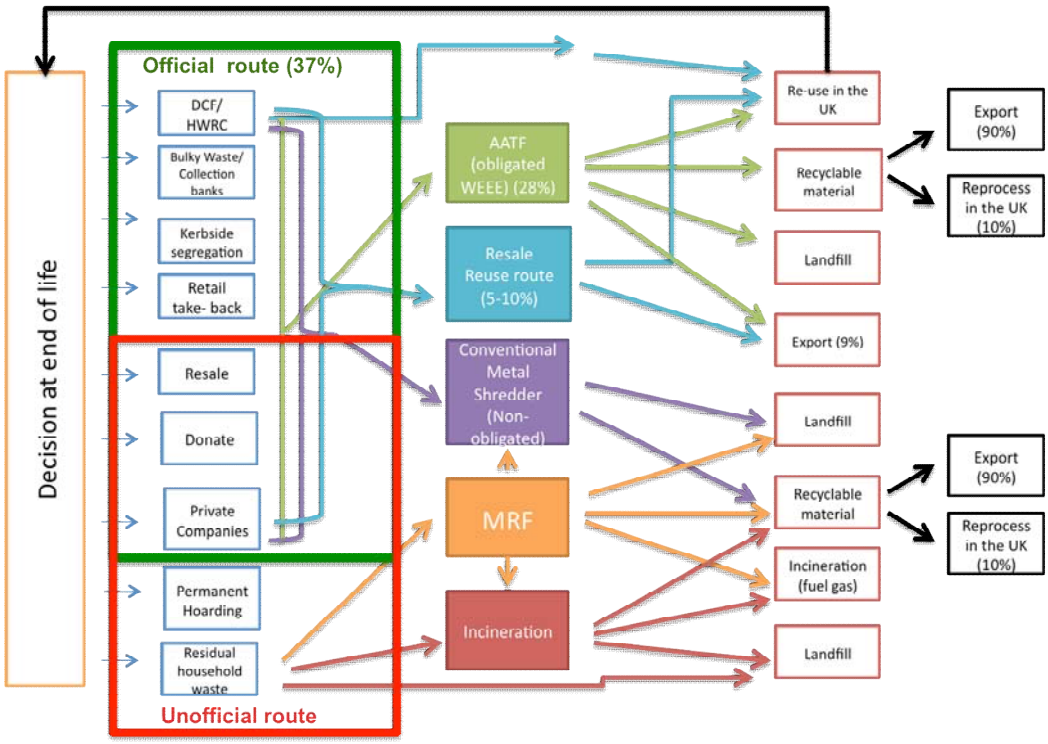

Figure 3: WEEE disposal routes in the UK (adapted from WRAP 2011)

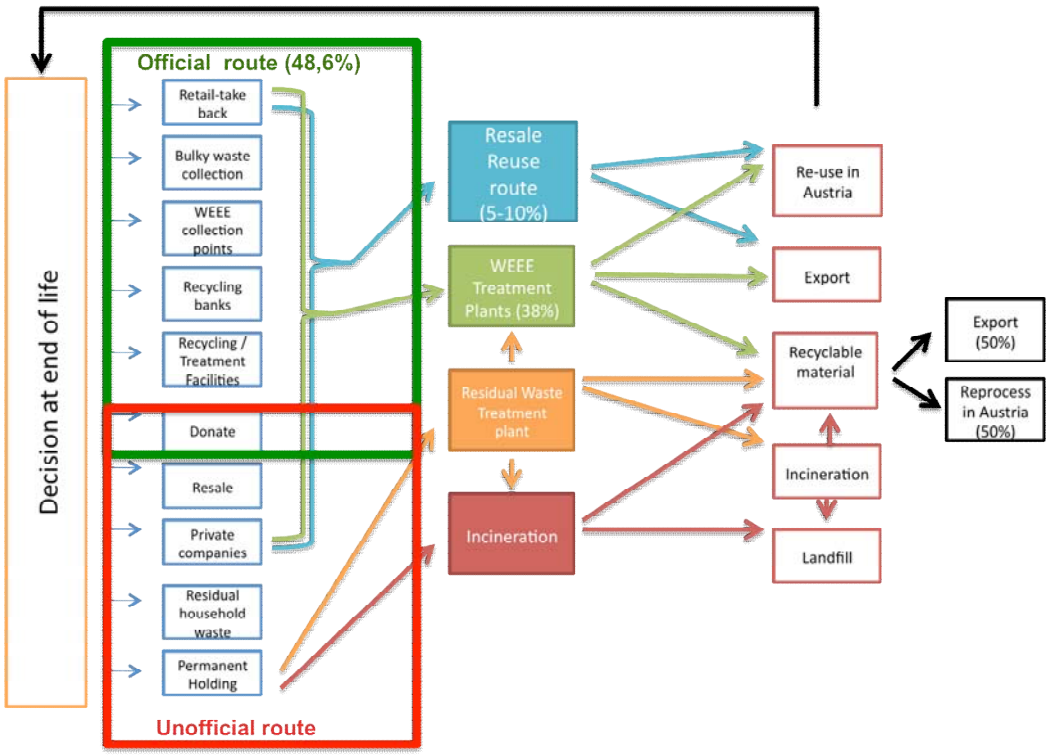

Figure 4: WEEE disposal routes in Austria

3.1 Implementation of the EU regulation

The EU Commission required the MS transferred the WEEE directive into national law by 13 August 2005. The UK has postponed its implementation several times until it got a formal notice from the EU in mid 2005 requesting an explanation from the UK government for its delay. Finally, in July 2006 the UK Department of Trade and Industry (DTI) (now known as the UK Department for Business, Innovation and Skills) released a draft of the national WEEE Regulation open for consultation. The consultation closed in October 2006 but the final UK Waste Electrical and Electronic Equipment Regulation came into force only on 1st July 2007 (Turner and Callaghan, 2007).

Austria had already been operating a take back system for lamps since 1991 and one for cooling systems since 1993, before the implementation of the WEEE directive into national law in mid 2005. This already existing system and infrastructure has been a big advantage for the implementation of the directive (Cahill et al., 2010).

In both countries the EU WEEE directive was put into national law through two sets of regulations. In the UK the *WEEE Regulation 2006* is a copy-out of the EU directive and covers most of its aspects. Additionally the *Environmental Permitting Regulations* covers the directives requirement of WEEE treatment and side licensing. This regulation affects only England and Wales but ones similar are in force in Scotland and Northern Ireland (Environment Agency, 2011). In Austria the directive has been implemented through the *Waste Electrical and Electronic Equipment Ordinance* (Elektroaltgeräte Verordnung) and the already exciting O*rdinance on Waste Treatment Obligations* (Abfallbehandlungsverordnung), which covered in its 2005 amendment the WEEE treatment obligations of EU directives. The obligations regarding the RoHS directive are covered in the WEEE Ordinance as well (Umweltbundesamt, 2011; Lebensministerium, 2008). The UK RoHS regulations came into force on 1 July 2006. The UK Department for Business,

Innovation and Skills was charged with its implementation (Wright and Elcock, 2006; BIS, 2011).

Although the UK and the Austrian WEEE regulations cover all of the ten EU categories, they both have allocated them into different national collection and treatment categories (Table 3). Whereas the UK categorises the equipment into 13 product categories, in Austria only 5 categories exist. Furthermore, the UK WEEE Regulation categorises WEEE into obligated and non-obligated WEEE: obligated WEEE is the equipment listed in the regulation, non-obligated consist of any other non-listed equipment (Environment Agency 2011b, Lebensministerium, 2008).

UK WEEE categorisation	**Austrian WEEE categorisation**
1. Large household appliances 2. Small household appliances 3. IT and telecoms equipment 4. Consumer equipment 5. Lighting equipment 6. Electrical and electronic tools 7. Toys and leisure and sports equipment 8. Medical devices 9. Monitoring and Control instruments 10. Automatic dispensers 11. Display equipment 12. Cooling equipment 13. Gas discharge lamps	1. Large appliances (including IT, consumer equipment, electronic toys, etc. larger than 50 cm) 2. Small electrical appliance (including IT, consumer equipment, electronic toys, etc. smaller than 50 cm) 3. Cooling appliances, refrigerators and freezers 4. Display screen equipment (including appliances with cathode-ray tubes) 5. Gas discharge lamps

Table 3: WEEE categorisation in the UK and in Austria

Producer Responsibility

In the UK, producers are obliged to join a collective producer compliance scheme (PCS) that manages their reporting, financing and treatment responsibilities. In 2010 these obligations have been carried out by 41 different schemes in a competitive model, however there is no co-ordinating or representing body (Cahill et al., 2011). The compliance for treatment and recycling is reported in form of evidence notes issued from Authorized Approved Treatment Facilities (AATFs) or from Approved Exporters (AEs) (for WEEE received as whole and for reuse only). Additionally, an official exchange for the trade of these evidence notes exists (Turner and Callaghan 2007; Cahill et al., 2011; Environment Agency, 2011a).

In Austria the Federal Ministry of Agriculture, Forestry, Environment and Water Management approved five national collection and recovery systems for WEEE, (whereas one is for lightening equipment only) which act as compliance schemes. However, the producers have the option to comply individually or collectively through one of these systems. Each of the systems must set up WEEE transfer stations in each regional district in the country or conclude contracts with municipalities or municipal waste management associations to carry out these obligations for them. Regarding historical WEEE, the producer must join a compliance scheme for its collection (Cahill et al. 2011; Lebensministerium, 2008).

Distributers

The obligations of the distributors are to be followed in both countries by offering an in store take-back or by providing any other alternative take back system as long as they are still convenient for consumers. In the UK, the distributors also have the option to participate in a distributor compliance scheme (DTS), which acts in the same way as a producer compliance scheme (Cahill et al., 2011; Environmental Agency 2011, Lebensministerium 2006).

Local Authorities and municipalities

Whereas in the UK the WEEE regulations has not placed any direct obligation on local authorities, in Austria local authorities or municipalities are obliged to collect all WEEE out of the five categories mentioned above separately, free of charge for the consumers. The municipalities can follow these obligations either individually or by joining municipal waste management associations. For offering these collection services, the municipalities receive reimbursements from the compliance schemes by means of contractual agreements. As soon as the obsolete equipment is handed over at a collection point it becomes property of the municipalities or the waste management associations. Consequently they are obliged to ensure further treatment, which may be carried out by themselves or send on to other WEEE processing plants (Lebensministerium, 2008 Umweltbundesamt, 2011;). The municipalities may manage these treatment obligations individually, use the clearinghouse (EAK) or enter an agreement with the collection and recovery systems (compliance schemes) (Cahill et al., 2011).

In the UK, local authorities may voluntarily nominate their Civic Amenity (CA) or Household Waste Recycling Centre (HWRC) to be a Designated Collection Facility (DCF). If they do so, they have agreed and committed to support WEEE reuse and recycling as well as to comply with the BIS (Department for Business, Innovation and Skills) Code of Practice (WRAP, 2010a). DCFs have received a one-time compensation from DTS for setting up their collection facilities. Although there is no direct financial flow between the DCF's and PCS's, the producers (or compliance schemes) have to cover all costs regarding collection, transport and treatment of WEEE. Therefore they sign up contracts with the local authorities. For local authorities the collection of WEEE has the advantage of saving money by not being responsible for the treatment and disposal. Furthermore it contributes to meet their statutory recycling targets (Environment Agency, 2011; Cahill et al., 2011; WRAP, 2010a).

Whereas the UK has not introduced a coordinative body for WEEE collection, in Austria a national clearinghouse was established together with the WEEE

regulations (Eletrogeräte Koordinierungsstelle Austria (EAK) – Electrical and Electronic Support Service Austria). The EAK determines the compensations from the producers for the local authorities and evaluates the market shares. Additionally it acts as a co-ordinating and representing body for collection and take-back systems across the country. It is responsible for reporting the quantities and other data to the federal government and the European Commission (Elektroaltgeräte Koordinationsstelle, 2005).

The implementation of the European directive did not only imply a change in the global electronic industry but was also linked to enormous costs. The UK government has estimated that the implementation of the WEEE directive will cost the UK around £100 million (€ 112.5 million) (Turner and Callaghan, 2007). The Austrian Chamber of Labour estimated in 2005 the additional cost caused by the regulations and carried only by the consumers, up to € 95 million (£ 82,4 million). Additionally the electronic industry, the distributors and the local authorities had to deal with enormous cost increase (Bauer, 2005).

3.2 WEEE quantities

In the UK about 1 million tonnes of WEEE are generated every year. In 2009 5814 registered producers were responsible for a total of 1.2 million tonnes of household EEE set on the market. According to the Environment Agency (2011a), in the same year 454,000 t. of household WEEE were collected accounting for a collection rate based on the EEE put on market of approximately 37%. The per capita amount collected reached 7.3 kg in 2009 (letsrecycle, 2010).

In Austria in 2009 a total amount of 153,747 tonnes of household EEE products were placed on the market by 1724 registered producers. A total amount of 74,785 tonnes of household WEEE were collected leading to a collection rate based on the EEE set on the market of 48,6%. The per capita collection rate accounted for 9.32 kg in the same year (Elektroaltgeräte Koordinationsstelle, 2009).

Figure 5 and 6 show the composition by categories in percentages of the total household WEEE collected in the UK and in Austria in 2009.

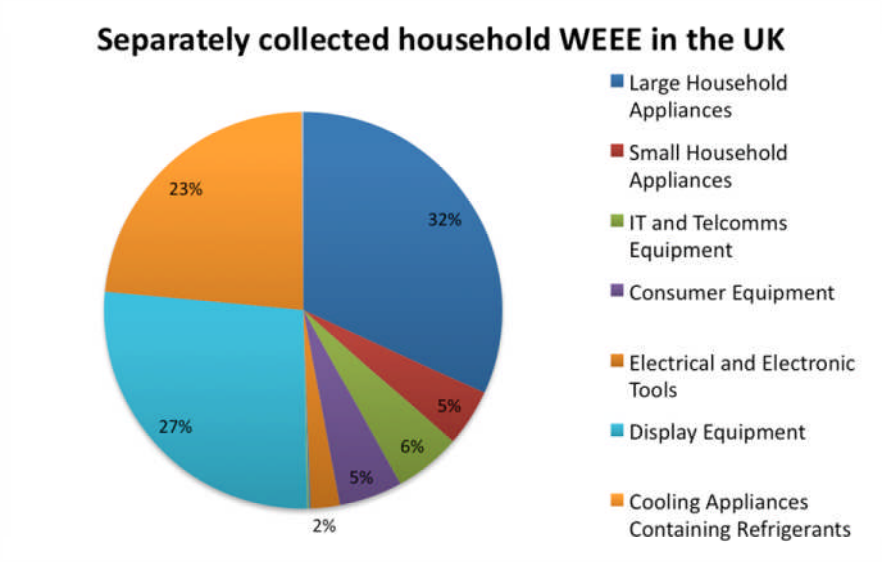

Figure 5: Separately collected household WEEE in the UK in 2009 (adapted from the Environment Agency, 2011). Categories accounting for less than 1% are not shown

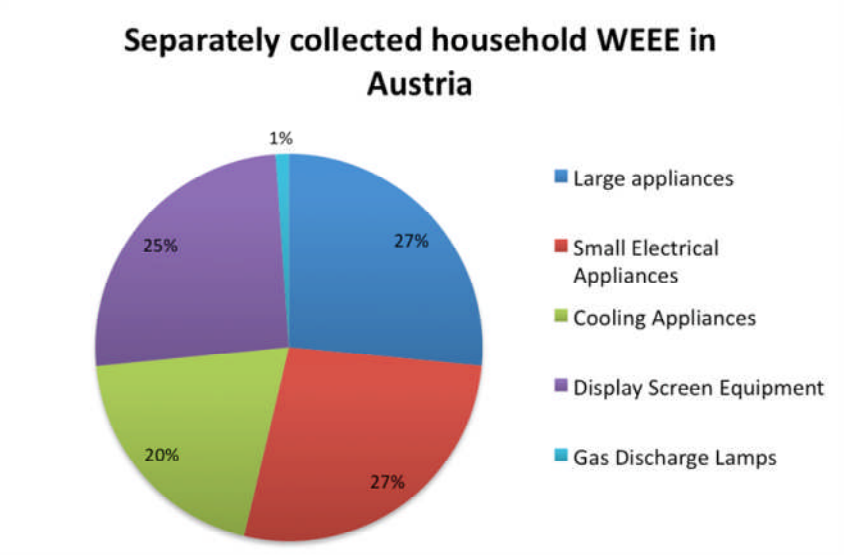

Figure 6: Separately collected household WEEE in 2009 in Austria. (EAK, 2009). Categories accounting for less than 1% are not shown

Different national WEEE categorisation lead to difficulties in undertaking comparisons. Appendix A3 shows the Eurostat WEEE data published by the European Commission for the year 2008. This dataset allows a detailed comparison since the EU WEEE categorisation has been used.

3.3 Consumer attitude towards recycling

Recycling can only be carried out if the consumer participates in the system. This is to say, that the consumers attitude and willingness to recycle is fundamental. The consumer's motivation to recycling is not only linked to behavioural factors but also to socioeconomic factors (WRAP, 2007).

A survey published by the British ERP (European Recycling Platform) points out that the biggest challenge the WEEE industry has to face in the UK is public awareness. An environmental concern among Britain's population does exist, but it is not an issue given high priority (WRAP, 2007; MORI Social Research Institute, 2002). The majority of the British people support recycling actions, however *"the transient nature in which it is considered appears insufficient to establish and maintain habitual patterns of recycling"* (MORI Social Research Institute, 2002, p. 4). Nevertheless, according to the ERP survey the situation is slowly improving since recycling rates are increasing every year.

On the other hand, according to a survey undertaken by the Eurobarometer in Spring 2011, the Austrian citizens see themselves as committed to the environment and willing to carry out recycling actions in their everyday life. According to the Austrian European Recycling Platform, this is due to the fact that there has always been an established recycling culture and infrastructure in Austria (ERP, 2011).

According to Mill (2011) recycling is directly linked to understanding and knowledge, as many consumers don't know that their obsolete electrical and electronic goods can be recycled and where. Mill (2011) further states that in the UK more has to be done in knowledge transfer and rising awareness. For

example recycling campaigns are an effective instrument for spreading the message about WEEE recycling in the public, however they are very costly and financial support is lacking for the councils to launch them.

An already existing nationwide British recycling campaign for small WEEE is “Don’t bin it, bring it” created and run by WRAP for small WEEE collection. It spreads out the message about the importance and benefits of recycling all around the country in form of TV, radio and press advertisements. Due to the fact that this campaign was still running at the time of this project, it was not possible to obtain any results regarding its success (WRAP, 2011a). However, results are obtained from two other successful British campaigns launched by Kent County Council and Leicestershire County Council. Both of the County Councils have raised awareness among their residents through public communications efforts and increased small WEEE recycling remarkably, up to 43% (WRAP, 2010). Likewise in Austria motivation and communication plays an essential role in waste management. According to the Austrian waste management authorities, in order to increase WEEE collection the primary focus has to be set on raising knowledge and awareness in the public through information campaigns.

Furthermore, the willingness to recycle is directly linked to its inherent effort. A study carried out in Wales in 2002 reveals that 88% of the questioned household would recycle more if a kerbside collection service would be provided (Darby et al., 2005). Also in Austria an increased motivation to recycle is observed with a user-friendly system. That is to say, a short distance to an easy to use collection facility or service has a big impact on the consumer attitude to recycling (Salhofer, 2009).

3.4 Collection systems and routes

3.4.1 United Kingdom

The recycling and collection infrastructure in the UK is very variable: the British consumers have the choice of either bringing their redundant equipment to a council's HWRC or to any other community recycling point (e.g. in supermarkets or recycling banks). They might also bring it back to the retailer, use the pickup services from councils or waste management companies or give it to charity or social organisations (Darby and Obara, 2005).

As mentioned above, the British WEEE regulation does not include any obligations for local authorities. Yet municipal collection sites are essential for WEEE collection. The British citizens disposed 82% of their e-waste on DCFs in 2010. The rest (18%) of the officially collected WEEE in 2010 was returned by distributors through producer compliance schemes or through a different collection system operated by producer compliance schemes. This WEEE flow consisted of mainly large household appliances (49%), cooling appliances (28%) and display equipment (12%) (Environment Agency, 2011a).

The collection services offered by the DCFs are free of charge for consumers. On the other hand for the bulky waste collection services the councils usually charge a fee. These fees vary from council to council (e.g. Cornwall's Councils charge £15 for 1 collected item and £7,50 for any additional (maximum 4), whereas in Milton Keynes the bulky waste collection is free of charge, unless the resident wants the collection on the same day, then a £10 fee is charged) (Cornwall Council, 2011; Milton Keynes Council, 2011).

The infrastructure for large household appliances recycling in the UK is considered to be the best in terms of British WEEE recycling (Goosey, 2009). This would explain the fact that large household appliances account for more than 50% of the overall WEEE collected; yet, this is a weight-based rate. The collection route of large household appliances in the UK consists mainly through

CAs but also trough the retail take-back scheme (e.g. the take back of a machine when delivered a new one) and the council's bulky waste collection. A 2006 undertaken WEEE flow analysis of London, states that the three main disposal routes for large household appliances are taking them to local civic amenity sites (31%), using the retailer take back services (22%) and discarding them through the council's bulky waste collection (16%). Other disposal routes may be selling privately, donating to charity, disposing through ordinary waste or fly tipping (Environment Agency, 2011; Goosey, 2009; Enhance, 2006).

Regarding small WEEE disposal, a considerable amount still terminates in the residual waste. The reason for this is the diversity, the small value and limited re-use market for obsolete small household appliances (Darby and Obara, 2005). A survey undertaken in Wales indicates a lack of awareness surrounding the disposal of small WEEE, since a considerable number of related questioned were answered as "not relevant" or simply being ignored (Darby and Obara, 2005). Other studies claim that up to 60% of the small EEE may be disposed in the residual household waste (Darby and Obara, 2005). Yet, only 14% of small WEEE was actually collected in 2009 (Environment Agency, 2011). Nevertheless waste authorities have recognized the problem and try to raise the small WEEE collection rate through rolling out collection banks, provide kerbside collection services and organize collection events and campaigns.

3.4.2 Austria

The main difference between the Austrian and British WEEE collection system is the fact that the Austrian WEEE ordinance did pass obligations to local authorities and municipalities. Therefore the municipalities, either on their own or through municipal waste management associations, are obliged to set up WEEE collection points. These obligations should guarantee a nationwide collection network to ensure that every citizen has the possibility to dispose of discarded equipment for recycling. Consequently more than 90% of the

collection of WEEE in Austria takes place at the 1900 municipal waste collection sites (EAK, 2010a; Lebensministerium, 2008; EAK, 2007).

In most cases the municipalities join together to waste management associations to take care of the collecting and the setting up of household waste recycling centres. For instance in Upper Austria the 444 municipalities merged together to form 18 waste management associations which set up 185 household waste collection centres or so called “recyclables collection centres” (RCC). A company owned by these waste management associations, Landes-Abfallverwertungsunternehmen (LAVU) AG, is in charge of planning, establishing the infrastructure, controlling as well as of any staff recruitments for these RCC. Moreover, this company is responsible for treatment and recovery of the recyclable material. LAVU carries out the dismantling of small electrical appliances by itself at its Waste Logistic Centre situated in the centre of Upper Austria. Treatment of other WEEE categories and further processing is carried out at contract based processing plants (LAVU, 2011; LAVU, 2010).

Although small WEEE accounts for the highest collection rate from the municipalities with 28%, the Viennese municipal waste management department claims that there is still a higher potential in this collection stream since a considerable amount is still found discarded in the residual waste (MA 48, 2011). Display and screen equipment, the second highest collected category (26%) accounts for the highest recycling rate in proportion to the products placed on the market. Yet, it has to be kept in mind, while the lighter LCD-screens are being sold; the heavier CRT screens are being disposed. The actual collection rate of large household appliances exceeds the amount collected at municipal collection points (25%) by far, because many consumers also take advantage of the retail take back scheme – e.g. when the retailer delivers a new washing machine the old one is taken along at delivery. Finally cooling appliances account for 20% and gas discharge lamps for only 1%. (Then again, it has to be kept in mind that according to the Austrian categorisation small WEEE includes any electrical and electronic goods smaller

than 50 cm, including computers, laptops, or any other kind of small household appliances etc.) (ERP, 2011; EAK, 2009).

Municipalities also offer a charged service for bulky waste and WEEE collection. For instance in Vienna the municipal waste management department offers a collection of cooling equipment for 17 – 34 € (£15,3 – 30,7) (based on the size) and 9 € (£8) for display screen equipment. The municipalities in Upper Austria either collect the waste free of charge or charge a fee of 5-15 € (4,5 – 13,5 £) per m^3. Additionally, in some Austrian cities, WEEE may also be collected through a free of charge bulky waste kerbside collection service once or twice a year. However, this collection route has been more common before the implementation of the WEEE directive and the retail take-back scheme. Therefore WEEE are accepted but not welcome in this kind of bulky waste collection, yet WEEE only accounts for a small percentage in this waste fraction (Lebensministerium, 2011; Stadt Salzburg, 2011; MA48 2007a; LAVU 2011a).

Furthermore many municipalities offer additional separate collection points for small WEEE together with other types of hazardous waste. These collection banks and containers are found either at stationary collection points or as mobile collection services following a specific route weekly or every other week. Nevertheless, according to the Viennese municipal waste management department a trend towards using the household waste recycling centres is observed and fewer residents discard their small WEEE in such collection points (MA48, 2007b).

In addition to the municipal waste collection and the retailer take back scheme consumers have the option to bring their discarded equipment directly to the waste disposal and treatment facilities. This collection route would mean less logistical expenses for the collection and treatment schemes but is more common among retailers than consumers (Lebensministerium, 2011).

3.4.3 Reuse

Reuse is an important issue in WEEE management. The overall re-use rate in the EU accounts for 2%, however it should be given more priority in the future according to the European Commission (2011).

The Environment Agency data of 2009 indicate, that an amount of 26,132 tonnes of WEEE where officially registered from AATF for any kind of reuse in the UK. This accounts for 6,5% of the total amount being collected and a 2% reuse rate in relation to the total EEE put on market in 2009 (Environment Agency, 2011a). To ensure the quality of the equipment and prevent export of non-functional equipment being declared as functional the PAS141:2010 standardisation has been developed in 2010 as best practice guidance for WEEE reuse activities. PAS141:2010 standardisation requires records of the tests carried out and sets out specifications for organizations involved in WEEE reuse (Adams, 2011).

The reuse proportion of WEEE in Austria accounts for approximately 5% of the amount collected. Its potential is estimated to double since the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management announced in its waste strategies in 2011 that more emphasis will be given towards WEEE reuse. Consequently there is a number of projects and networking organisations, which are dealing with re-use, on a national and on transnational basis e.g.: RepaNet, EcoNet-Austria, RUSO, RepaM (Neitsch, 2011, Spitzbart et al. 2009).

3.4.4 Illegal export

Every year 23,000 tonnes of undeclared e-waste are illegally exported from the UK to non-OECD countries (Greenpeace 2009). Law perpetrating recycling companies are involved in these illegal actions. To prevent these illegal activities waste and recycling companies are obliged to be registered, however

operator claim that the official system still leaves too many “loopholes” (letsrecycle 2011c).

The reasons for this exportation are to take advantage of cheap labour and lack of environmental standards in these countries. High processing costs and strict regulation in the EU make it economically attractive to export the e-waste for dismantling into a developing country. A rising market for both, secondary raw materials as well as the market for second hand electrical devises in these countries make these illegal activities to be a big business, in which WEEE is still declared as functional second hand products (Environment Agency 2011; UBA, 2010).

Also Austria has to face the problem of illegal export of WEEE. However the main problem concerning this issue is the waste collection by non-authorised people, the so-called informal waste collections. These activities involve waste collection of recyclable materials that are further processed or resold in Central and Eastern European Countries. According to a project carried out by the Institute of Waste Management of the University of Natural Resources and Life Science in Vienna, 23% of these informal waste collection activities concern WEEE collection. According to Obersteiner et al. (2010) an estimated 80,000 tons of items are informally collected each year, containing an estimated 20,800 tons of WEEE. Furthermore 65,000 tonnes of these items are transhipped over the Austrian-Hungarian border. Consequently, the CENTRAL EUROPE programme and the ERDF (European Regional Development Fund) are financing a project lead by the Institute of Waste Management of the Austrian University of Natural Resources and Life Science with further partners Austria, Germany, Hungary, Poland and Slovakia to develop a sustainable solution for formalising this informal waste sector (Obersteiner et al., 2010).

Although Austria has no access to the sea and therefore no harbours, the problem of illegal export to non-OECD countries is still an issue. According to the Südwind Agentur (2008), an Austrian Information Service for International Development Policy, non-functional electronic goods from Austria are found in

containers of illegal e-waste export in major European harbours like Hamburg and Rotterdam.

3.5 Processing and treatment

According to the Environment Agency (2011a) 436,653 tonnes of household WEEE, therefore 96% of the amount collected, were registered as being “received for any kind of treatment” in 2009 at an Approved Authorised Treatment Facility (AATF) in the UK. The total achieved recovery rate in the UK for 2008 accounts for 74% whereas the total achieved reuse and recycling rate accounts for 71% (European Commission, 2011).

A survey carried out by the Austrian Environment Agency in 2006 states that 59.540 tonnes of WEEE were treated, which accounts to 95% of 62.627 tonnes collected (Tesar et al., 2006). The data published by the European Commission in 2008, show that the total achieved recovery rate in Austria for the same year accounts for 88%, whereas the total reuse and recycling rate accounts for 77%.

Figures 7 and 8 show the different “recovery “and “reuse and recycling” rates for each category in 2008 in the UK and Austria, respectively (European Commission, 2011).

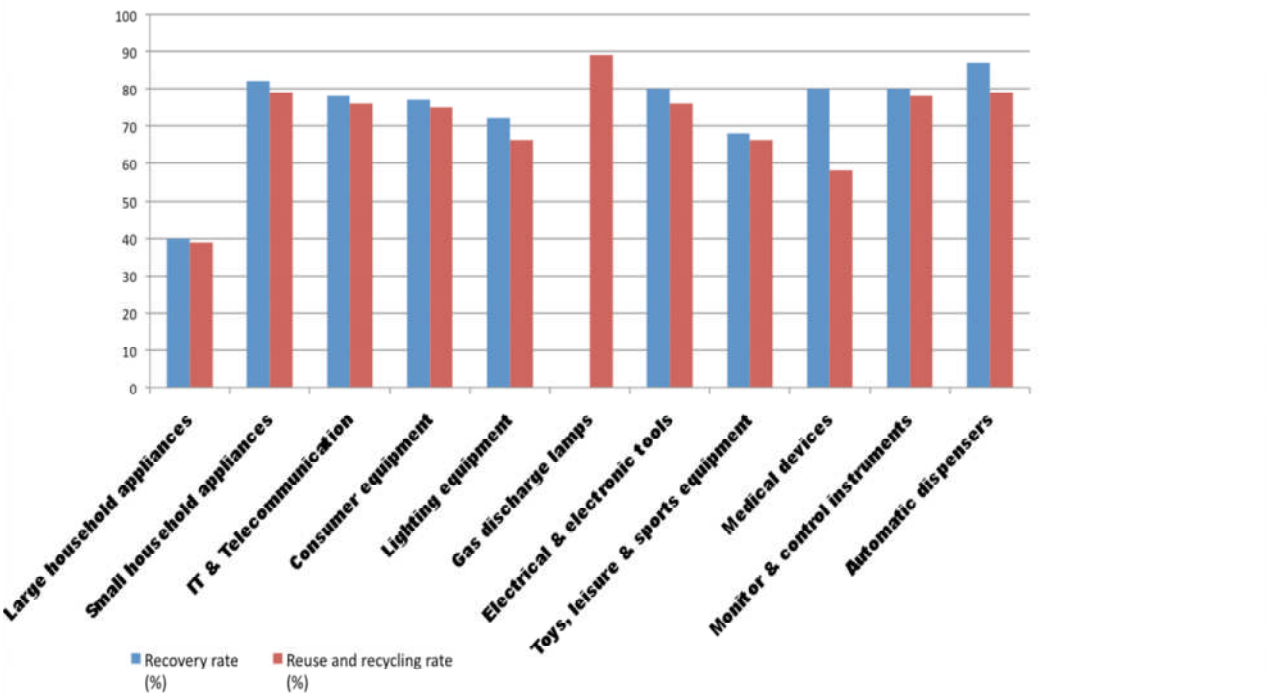

Figure 7: Recovery, Reuse and Recycling rate for the UK in 2008. (European Commission 2011)

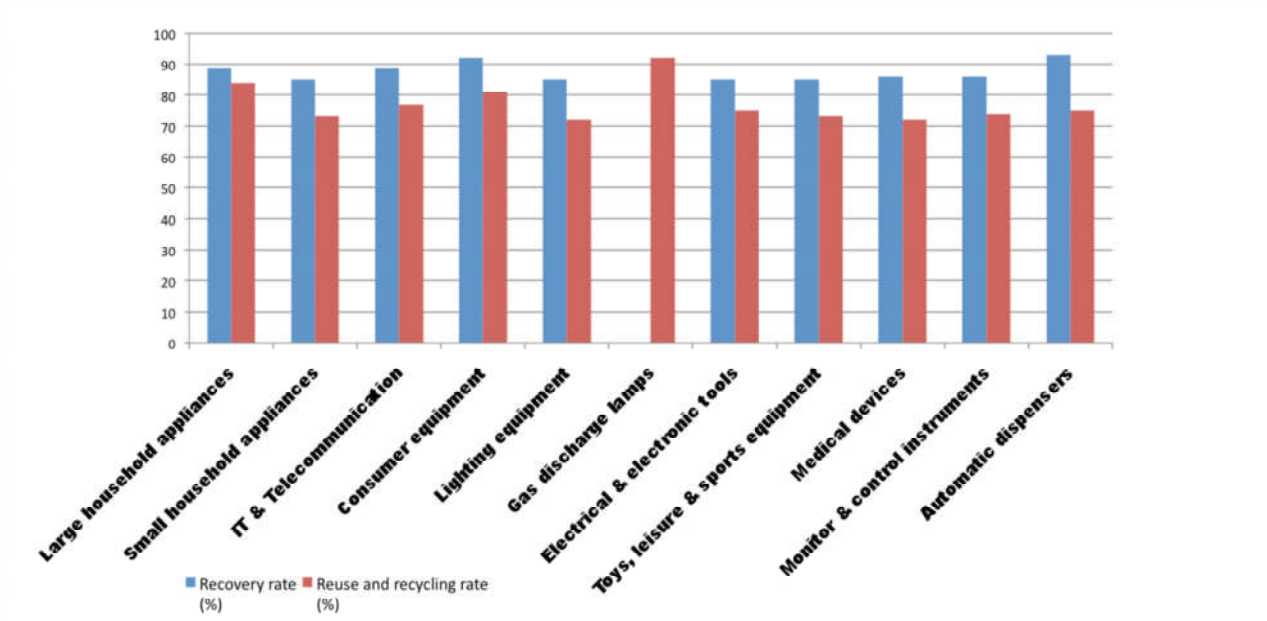

Figure 8: Recovery, Reuse and Recycling rate for Austria in 2008. (European Commission, 2011)

In 2011 over 200 AATFs for WEEE were registered in the UK with the Environment Agency (2011b). These treatment facilities sort, treat, pre- and/or reprocess all kinds of EE waste and are specialised in different categories and stages in the recycling process. Among them many different types of waste management companies can be found. For instance waste management companies specialized in hazardous waste or in any other kind or aspect of waste somehow linked to WEEE. Charities, which collect equipment for reuse, are registered as an AATF as well as other companies regarding reparation, refurbishment and resell of IT equipment. For instance, refrigerators recycling companies, cathode ray tubes (CRT) recycling companies or metal recyclers. The size and capacity of these plants is very variable. Regarding large WEEE processing plants, for instance, the “European Metal Recycling” (EMR) runs a plant of a capacity of one million fridges per year. “EnvironCom”, runs a plant with a 100,000 tonnes capacity and the reprocessing companies “SWEEEP” and “Overtone” are each running plants with a total capacity of 80,000 tonnes per year for all kinds of electronic goods. Nonetheless, according to letsrecycle.com all these facilities are currently operating below capacity. “SWEEEP” for instance, is running at 40% capacity. The operators claim that this is caused by the recession, illegal export and inefficient collection (letsrecycle, 2011c; Seek-It, 2011; Environment Agency, 2011).

Currently there are 58 registered WEEE process and treatment plants in Austria (Lebensministerium, 2011). As in the UK, different processors are specialised in different categories and stages in the recycling loop. Unlike in the UK, waste management authorities in Austria also process WEEE. Yet this kind of plants only pre-process, in terms of separation, manual dismantling. For instance the Upper Austrian Landes-Abfallverwertungsunternehmen (LAVU AG) undertakes the manual dismantling of cooling appliances, display screen equipment and small household equipment (LAVU, 2010). If the municipalities process WEEE themselves, they have contracts with the compliance schemes on behalf of WEEE collection and treatment. Consequently after pre-treatment they are in charge of further processing, which has to be proven to be traceable and according to the law. Hence additional contracts are to be concluded with waste

treatment and recycling companies. On the other hand the municipalities receive compensation for the recoverable materials from the treatment companies. The compliance schemes compensate them for the amount of WEEE collected and treated based on kg, contract and market shares (Abfallwirtschaftsverband Feldbach, 2011; LAVU, 2011).

The capacity of large WEEE process plants in Austria is similar to the ones in the UK. For instance “Scholz Rohstoffhandel” as well as “Gebrüder Gratz GmbH” operate each a plant of 120,000 t/yr capacity, “Loacker Recycling GmbH” 80,000 t/yr or “TSG Tiroler Schredder GmbH” 60,000 t/ yr. So far these are recycling companies specialized on any kind of metal shredding, therefore the material has to be already pre-processed before being treated in these plants and WEEE is just one out of other input materials. On the other hand WEEE treatment specialists like “Elektronikaltgeräte Recycling West GmbH” (small WEEE) or “NÖ Kühlgeräte Entsorgungsgesellschaft m.b.H.” (cooling equipment) operate under much smaller capacities (17,000 t/yr, 1,600 t/yr) (Tesar et al., 2008).

As in the UK, Austrian operators claim to run under capacity. Nevertheless, they state that there would be enough material but the short run may be caused by insufficient collection efficiency from municipalities and the fact that not all WEEE is actually treated in the country itself (Abfallwirtschaftsverband Feldbach, 2011; LAVU 2011; Mueller-Guttenbrunn, 2011).

In order to secure material input, processing and treatment facilities in the UK and in Austria enter into contracts with compliance schemes, local authorities or municipalities, waste management companies or any other clients e.g. universities and businesses. Still the amount of material being processed and recycled depends strongly on the quantity being collected from households. Operators in both countries claim that much more has to be done to address awareness and raise the amount being collected to achieve a higher proportion of WEEE recycling, since much more potential exists. For the recovered material further contracts are signed with refineries or metal smelters, either

inland or abroad, or with further process plants (letsrecycle, 2011c; Seek-It, 2011; Abfallwirtschaftsverband Feldbach, 2011; Ma 48, 2011; LAVU, 2011).

British operators state that most of the recovered material is not being reprocessed neither refined in the UK. For instance one company states that its printed circuits boards are further exported via approved exporter to another EU country for material recovery. Recovered metals are mainly sold to a metal recycling company and either further exported or refined in a metal smelter in the UK. Compressors are exported via approved exporter to Pakistan. Plastic is sold for further treatment to a plastic shredder in the UK and terminates in China or is exported directly to China (Anonymous; 2011).

The research and survey carried out in the course of this project show that not as much of the recovered material is exported from Austria as from the UK. For instance most of the copper is refined in a copper refinery in Austria, for instance in Tyrol. Also ferrous metals, aluminium or other non-ferrous metals are mainly refined in Austria. Regarding plastics, for example the company MBA Polymers Austria (www.mbapolymers.at) produces plastic granulates and flakes out of electrical and electronic devices. Nevertheless the largest share of plastic, either recovered or refined, is exported to China where most of the manufacturing and reprocessing is taking place. Regarding the hazardous materials, 80% is exported and 20% is treated inside the country (Abfallwirtschaftsverband Feldbach, 2011; LAVU, 2011; Mueller-Guttenbrunn, 2011, Tesar et al., 2008).

Figure 9 and 10 show the possible material flow for WEEE in the UK and in Austria, respectively.

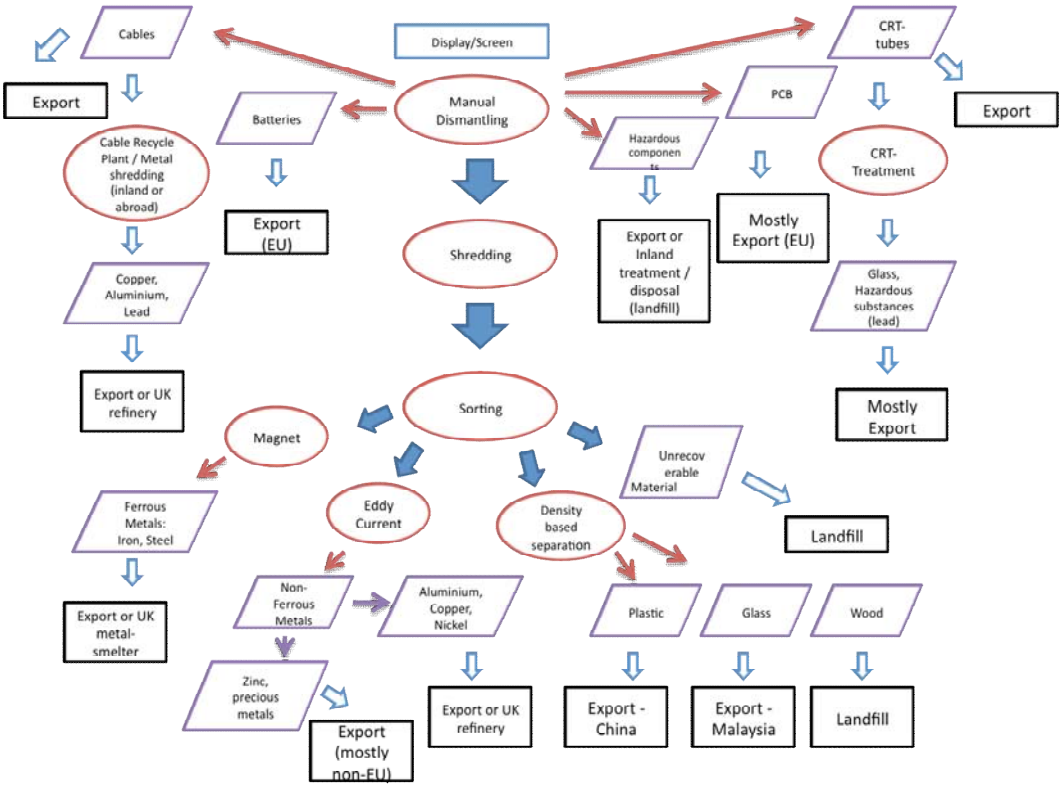

Figure 9: Suggested WEEE material flow in the UK

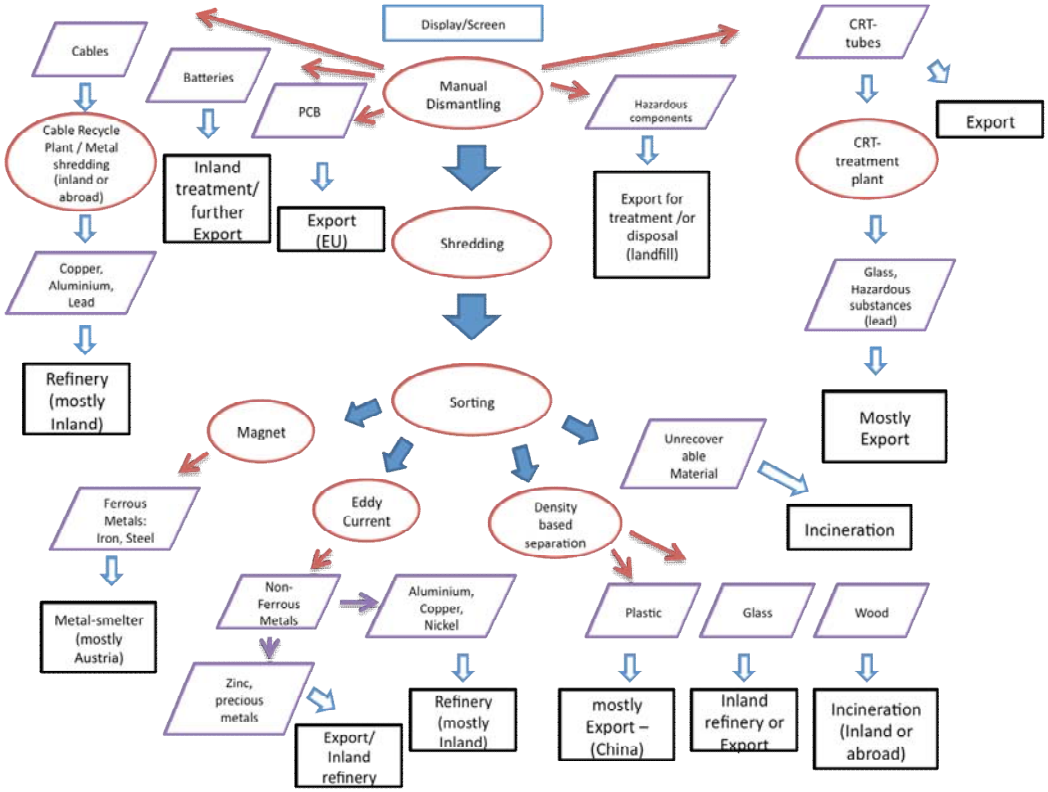

Figure 10: Suggested WEEE material flow in Austria

3.6 WEEE market analysis

The value of discarded electronic or electrical equipment is very hard to determine. It depends strongly on its components and its market-based value. This value is very inconsistent since it does not only vary from market to market but also from system to system (Leroy, 2011). However, it can be said that electronic equipment is of higher value since most of the valuable substances are found in electronic components (e.g. printed circuit board, condensors and processors, motors, magnetic coils). According to Streicher-Porte (2006) the overall economic value of discarded equipment consists of its content and market value of materials, the economic threshold level for the recycling activity, the size of the equipments stock, the mean lifetime and the maximum recycling rate. In consideration of the economic value of e-waste also the price of oil and energy has to be taken into account. In terms of costs, they both have a direct influence on the manufacturing process, the recycling rate and transport (Streicher-Porte, 2006).

The actual cost of recycling varies as well from type to type and further from the used recycling technology. However, it can be assumed that the overall recycle cost equals the sum of the costs from collection infrastructure, transport, recycling and system administration as well as technology costs minus the material revenues (Streicher-Porte, 2006).

Recycling of e-waste started in the 1950's driven by the economic value of copper and other metals contained in the discarded products. Copper price is still an important incentive for e-waste recycling among other metal prices. These prices have a crucial impact on the recycling prices and the recycling rate but also on the material recovery processes and techniques (Streicher-Porte, 2006). Table 4 shows the current recycled metal prices on the UK market in May 2011 (letsrecycle, 2011d):

	January 11	February 11	March 11	April 11	May 11
Non-Ferrous Metals	**(£/tonne)**	**(£/tonne)**	**(£/tonne)**	**(£/tonne)**	**(£/tonne)**
Heavy Copper	4700	4800	4800	4500	4200
Copper Wire	4300	4400	4400	4100	3800
Heavy Brass	2900	2900	2800	2800	2600
Pure Aluminium	1050	1050	1100	1100	1150
Lead scrap	1050	1000	1050	1100	1050
Zinc cuttings	600	600	650	600	650
Ferrous Metals					
Heavy Steel scrap	209	190	185	185	185
Light Iron	209	180	160	160	160

Table 4: Prices for recycled metals in the UK in May 2011 (letsrecycle, 2011d)

In contrast to table 4, table 5 shows the pure metal prices according to the London Metal exchange on June 7th 2011 and the conversion into British Pounds according to the UniCredit exchange rate on 5th July 2011 (1£= 1,58 $; 1 oz. tr. = 31,1034768 gram).

Virgin Metal Prices	$/tonne	£/tonne
Steel	604,00	347,43
Copper	9097	5497
Lead	2470	1492
Zinc	2252	1361
Aluminium	2626,5	1587
Aluminium Alloy	2350	1420
	$/troy ounce	**£/troy ounce**
Gold	1541	931
Silver	36	21,75
Palladium	801	484
Platinum	1815	1097

Table 5: Pure metal prices according to the London Metal Exchange in June 2011. (LME, 2011)

The value of the material is very fluctuating, so is the value of WEEE as a whole. According to the Viennese MA 48 (2011) for this reason the bulk prices of the collected materials are re-negotiated every month between the collection authority and the recycling plant, since the prices depend on the current market value of the metals. Furthermore, the MA 48 states that the actual market value of the components of recovered materials is estimated to be about 10 times higher than the compensation, which the collecting authorities are receiving. In June 2011 the actual value of a PCB was around 5,000 € per tonne (£ 4,420) and of cables between 1,000 and 2,000 € (£ 884 – 1768) which is more or less European standard. Table 6 shows the current Austrian metal prices according to the FEEI (Fachverband der Elektro- und Elektronikindustrie – Austrian Association of the Electrical and Electronic Industry) on 6th July 2011. These prices are based on the current London Metal Exchange values but show a slight difference due to exchange rates and national economies.

Metals	€/ 100 kg	€/tonne	£/tonne
Aluminium	173,45	1734,5	1533
Lead	179,72	1797,2	1588
Copper	636,02	6360,2	5622,42
Nickel	1.570,19	15701,9	13879,68
Zinc	157,4	1574	1391,42

Table 6. Metal Prices according to the Austrian FEEI (FEEI, 2011)

A further impact on the economies of WEEE recycling is the content of rare earth metals. Rare earth elements are found e.g. in mobile phones, loudspeakers, hard drives, batteries and catalyst. They consist of 17 elements and are essential for modern electronic equipment. China, who has been supplying around 97% worldwide of the rare earth elements, has cut its export by about 35% just recently and is still thinking about lowering this rate. The recycling and recovery of these metals is not only economically attractive but also essential in terms of material scarcity. Yet, according to the German

Institute of Applied Ecology (Schüler et al., 2011), no large scale recycling for rare earth elements has been developed. There are only a few industrial recycling activities currently being implemented, given that the recycling processes of rare earth elements is very complex, expensive and requires relatively a lot of energy, since a physical and chemical treatment is necessary for recovering these elements (BBC, 2010; Waste Management World, 2011; Schüler et al., 2011).

The components plastic and glass don't have the same economic value as metals. Nevertheless, if the disposal costs are taken into account, the recycling of for example CRT glass or the use of recycled plastic from WEEE mixed with virgin plastic does have an economic advantage. WRAP points out that there would not be any barriers from the consumer side for the purchase and use of electronic equipment containing recycled material (WRAP, 2011). Consequently the British Indesit Company started a pilot project together with a plastic moulding company producing access panel plates for large household appliances made out of recycled plastic, likewise from large household appliances. The results of this project state that the use of recycled plastic yields a 5% saving in raw material and not any remarkable losses in the material quality. Nevertheless, the blending of recycled and virgin material would still increase the quality (WRAP, 2011).

With the implementation of the WEEE directive, the producer responsibility has been introduced in the UK as a market based instrument. Consequently, the UK WEEE market is led on a supply and demand basis in which up to 41 compliance schemes are competing based on a free market trading of evidence notes. Consequently the WEEE market in the UK is dominated by 5 compliance schemes: REPIC, Valpak, ERP UK, Transform and DHL WEEE Compliance (letsrecycle, 2007). Most of the schemes also run parallel a compliance scheme for the packaging directive. Still, the market is regarded as a growing market since targets have to be met. Therefore, the EU directives influence the market trends in a very strong way and so do national waste strategies and policies (Valpak, 2011; Mill, 2011; letsrecycle, 2009).

Unlike in the UK, in Austria WEEE recycling market activities are not as strongly based on economic incentives and the market is more regulated. There are only 4 national collection and recovery systems (compliance schemes) for WEEE, which are approved by the government:

1. ERA – Elektro Recycling Austria GmbH
2. ERP – European Recycling Platform
3. EVA – Erfassen und Verwerten von Altstoffe GmbH
4. UFH – Umweltforum Haushalt Elektrogeräte

The amount of WEEE collected by each scheme must be equitable to their market share. Therefore, according to the WEEE ordinance, the collection rate of each scheme must not exceed 10% of their market share (Lebensministerium, 2008). The UFH is market leader for large household appliances, holding 58% of the market share, ERA around 20%, ERP around 10% and EVA less than 5%. Regarding small WEEE, ERP is the market leader, followed by ERA, UFH and ERP (UFH, 2011; ERP, 2011 Ferth, 2006).

To sum up the WEEE system analysis, table 7 provides an overview of the main differences between the British and the Austrian WEEE recycling systems.

UK WEEE System	Austrian WEEE System
No regulation before the WEEE directive	WEEE regulation for cooling equipment and lamps in place before the WEEE directive
Focus on market based approach	Focus on regulative approach
Total of 1,2 million tonnes of household EEE put on the market in 2009	Total of 153,747 tonnes of household EEE products put on the market in 2009
7,3 kg per capita collected in 2009	9,3 kg per capita collected in 2009
Local authorities do not have any direct obligations passed over but may volunteer to register their HWRC or CA to a Designated Collection Facility (DCF)	Local authorities are obliged to set up collection points and collect WEEE in each regional district
Distributers may join a Distributer Compliance Scheme (DTS) or offer an in-store take back	No compliance schemes for distributer; in-store take-back only
Producers are required to join one of 40 PCS, which are competing on the UK WEEE market	Producers may comply individually or collectively; 4 PCS for WEEE only are authorized from the government
No coordinating body or clearing house	Elektroaltgeräte-Koordinationsstelle (EAK) acts as co-ordinating body and clearing house
DTS finance the setting up of DCF (one time payment); PCS are responsible for financing transport and treatment of WEEE	Producer compensate LA for collection based on market share and determined by EAK

Responsible for collection: Producer, Distributer Responsible for treatment: Producer Costs mainly carried by the private sector	Responsible for collection: LA, Producer, Distributer (in-store take back Responsibilities for treatment: Producer, LA Costs divided by public authorities and private sector

Table 7: Main difference between the British and the Austrian WEEE systems

3.7 Lessons learnt from Austria. How can it be applied to the UK to increase WEEE recycling?

The two analysed case studies show two different approaches of waste management and policies: Austria has a municipal based waste management, where municipalities or waste management associations are in charge of household waste collection and treatment, whereas the UK waste management is more based on the private sector. Both approaches have advantages and disadvantages; however, in terms of WEEE recycling the Austrian system shows to be more successful than the British one. While in Austria the directive has been introduced as a strict law with penalties and obligations, the UK has favoured more a reward, market based system. Not only regarding the compliance schemes, but also the role of the local authorities. While in one country local authorities are obliged to collect WEEE and set up enough collection points, the other one prefers incentives in order to engage authorities and the population to recycling. However, in both cases most of the collection takes place at municipal collection points. Therefore the biggest strength of the

Austrian system lies in the role of the municipalities, who have to fulfil their obligations of collecting and treating WEEE to comply with the law. By offering a good service with good infrastructure and good public communications, the municipalities or municipal waste management associations keep the collection rate high in order to meet their targets. Although most of the waste disposal authorities in the UK do also operate WEEE collection systems, a narrow nationwide collection network has not been achieved yet and a strong commitment of the local authorities is not as present. If it would be introduced, probably the collection rate could increase significantly. Yet, a functional system would be a combination of penalties and incentives (Cahill et al., 2011).

As mentioned above, also the Austrian market for compliance schemes is more regulated than the British one leading to the fact that a few PCS can focus on adequate treatment and recovery instead of having to establish themselves on a competitive market (Cahill et al., 2011). Again, this underlies the different approaches of policy implementation in the two countries and therefore it is difficult to say if one could be applicable to the other.

Regarding the market for secondary raw materials deriving from WEEE, a more developed market has been observed in Austria. More is treated and recovered in the country, leading to a better network and a higher nationwide demand, hence to a better working market. Consequently it can be said, if more would be invested in the treatment- recovery and reprocessing infrastructure in Britain, more WEEE could be recycled efficiently.

The Austrian Elektroaltgeräte-Koordinationsstelle (EAK) acts as a clearing house and co-ordinating body. It coordinates the WEEE collection of the local authorities and acts as a link between the local authorities and the PCS. In Britain this has not been done in order to avoid intervention in the market equilibrium. However, local authorities claim that the nonexistence of such an independent body leads to difficulties in nationwide coordination and cooperation and therefore affects the efficiency in the whole system. Therefore, introducing such a co-ordinating body could increase WEEE recycling (Cahill et al., 2011).

However, the population of Austria is much smaller than in the UK and so is the amount of WEEE being generated. Therefore the difference in size, population and economy and the fact of having an already existing, well-established recycling infrastructure and recycling culture contributed to the higher Austrian collection rate.

As shown on the Austrian example and observed in other European countries with high WEEE recycling rates, a centralized control system with executive power as well as the creation of a more favourable public attitude towards recycling in combination with convenient forms of WEEE disposal will increase recycling rates. On the other hand to achieve this, much more has to be invested in such a recycling system. This is to say, the Austrian system might be more successful in terms of higher recycling rates but since the public authorities have to carry higher costs, it is more expensive to the taxpayers. Overall, an effective and efficient system has to be balanced between centralized control with regulative instruments and a self-regulative market based system with economic incentives.

3.8 WEEE Recast - New Challenges: Case study Austria

The Austria WEEE collection rate for all WEEE in 2009 accounted for 47,2% based on the EEE put on the market the same year. Taking as baseline the EEE set on the market over the two previous years, the collection rate for 2009 would be according to the WKO, the Austrian federal economic chamber, around 40% (WKO, 2009). This number states, that the currently proposed 45% collection target for 2013 would be achievable, however the WKO claims that the 65% collection target is too ambitious and unrealistic. According to Huisman (2009) an amount of 12.7 kg per capita has to be collected in Austria in 2013 and 18.9 kg per capita in 2016 in order to achieve this target.

A survey taken within some Austrian waste management associations, states that 54% see this target as not realistic. The reasons are various, however the main ones are:

- missing public awareness and willingness to recycle,
- the fact that not all recycled or re-used WEEE enter the official recycling system and are therefore not being registered (e.g. if the consumer brings them directly to a treatment or re-use facility or if he or she re-sells them for re-use on a private basis)
- illegal export.

Especially associations in the east of Austria consider illegal export as the biggest challenge. Furthermore the questioned associations claim that the amount of EEE put on market does not correlate with the amount of WEEE arising, financial support is missing to invest in public relations and the distributers are still not engaged sufficiently in WEEE collection. Some associations in Lower Austria, Styria and Tyrol further state that their collection potential is almost exhausted since not much WEEE is found in the ordinary residual household waste anymore.

In order to achieve the new European collection target new measures have to be set by the local authorities and municipalities. Consequently the same survey states, that 23% of the questioned waste management associations have neither set any new measures nor planned any, since the collection potential in their municipalities is almost exhausted and the current collection infrastructure is capable to cope with a higher amount of e-waste. Nevertheless, if definite targets and guidelines are decided, they may be obliged to set new activities regarding WEEE collection. Further 23% claim that measures have been set already but no additional ones are planned. Another 8% have not set any measure yet but will do so in the future. The associations that have already set measures and keep doing so in future account for 46%.

All of the associations, which took part in this survey, claim that most activities have been done in raising awareness in the public. Additionally, almost the majority of them have also invested in informing and advising households about WEEE recycling. Technical measures, e.g. setting up more or larger collection

containers, expending the collection network or introducing a mobile collection service, were only observed occasionally. “Other” set measures are analysis of the residual waste or training of the stuff at the recycling centres. A detailed distribution in terms of the actual amount of these set measures is shown in Figure 11.

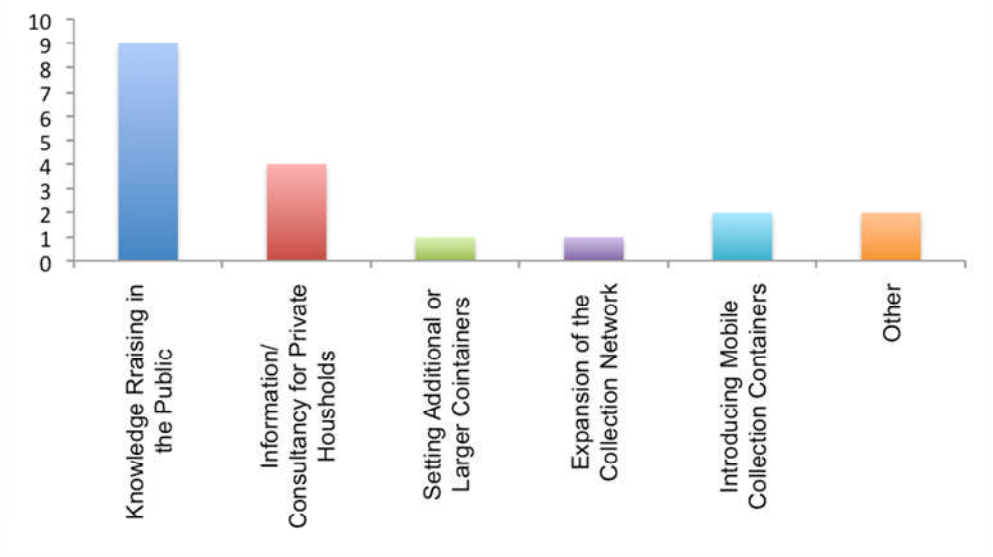

Figure 11: Distribution of measures already set by the Austrian waste management associations in order to raise the WEEE collection rate

The indicated planned activities show the same pattern: all of them include raising public knowledge and awareness. Again, more than half of the associations who are planning activities to raise WEEE collection will also provide consultancy and information to private households. Regarding technical measures, only some associations plan to provide additional or larger containers. “Other” activities are launching projects with schools, offering more help and advice at the recycling centres, focusing more on re-use or introducing activities against illegal export. Figure 12 shows the distribution of the planned measures by the Austrian waste management authorities in order to raise the WEEE collection rate.

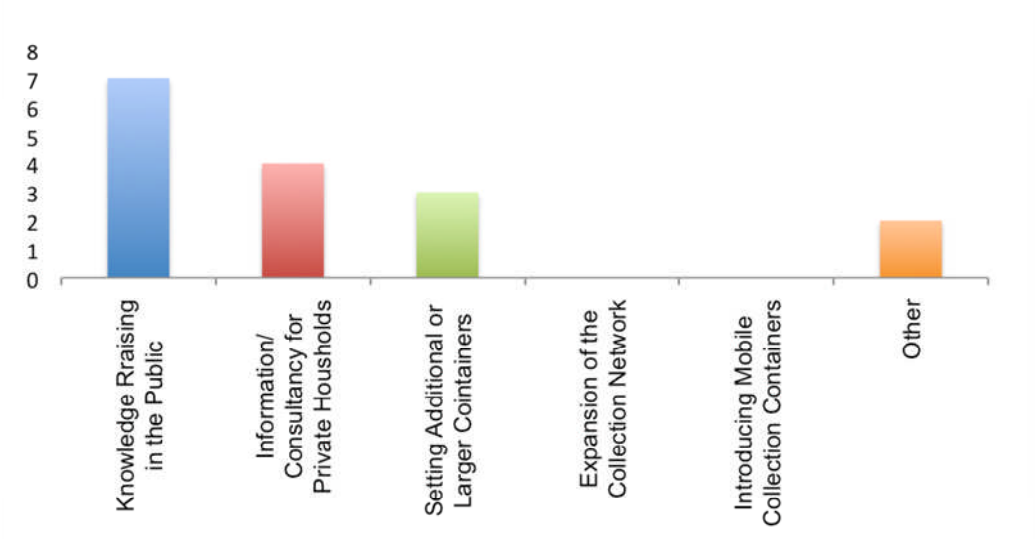

Figure 12: Distribution of planned measures from the Austrian waste management associations in order to increase the WEEE collection rate

To the question if the overall costs will increase, decrease or remain the same with a raising collection rate, 15% answered that they expect a decrease of the costs through optimisation or higher compensations from compliance schemes. However, 36% assume an increase, but the majority (46%) expects the costs remaining the same, even if more WEEE has to be collected.

Also the Austrian compliance schemes point out that the higher targets seem to be of a serious challenge. ERA (Elektro Recycling Austria) (2011) states, that the amount of EEE put on market and the amount of WEEE arising does not correlate, therefore a collection target based on the actual WEEE arising would be more realistic. Other challenges are seen in the fact that producers supplying EEE by means of distance communications are often not fulfilling their responsibilities although they should be registered in the country they sell to. This will lead to an increasing amount of free riders and resulting in loss of profit for compliance schemes. Therefore ERA is strongly supporting the introduction of stronger measures as well as more monitoring and controlling in order to tackle illegal shipment of WEEE and to stop and avoid material loss for the national economy (ERA, 2011).

From the economic point of view, the WKO (2009) points out that the proposed amendment still has too many negative effects for the Austrian economy. For example, too much financial responsibility is passed over to producers that will have a negative impact on the Austrian electronic industry. The WKO strongly disagrees with the proposal of the Commission, which suggests that member states should encourage producers to finance all the cost occurring for collection facilities from private households. The WKO states, that in Austria the current political consent should remain, in which the responsibilities are divided between local authorities, producers and the waste disposal industry. Furthermore, too many administrative and financial obligations are passed over to small and medium businesses (e.g. through 0:1 take back obligations, where all distributers are obliged to take back obsolete equipment, even if not a new, similar one has been bought), which are not always capable to carry these costs. These businesses are putting just a relatively small quantity of EEE on the market but have to follow the same obligations as much bigger companies do.

The WEEE recast bears many new challenges for WEEE management across all stakeholders, not only in Austria as shown above, but also for all European countries. Although increasing collection/recycling and recovery rates should ensure better resource recovery and improve environmental performance, for many stakeholders these targets are seen as too ambitious. Nevertheless, 46% of the questioned Austrian waste management associations do believe that Austria can reach these targets, however, still a lot needs to be done to reach them.

4 Associated Barriers to Recycling of WEEE

4.1 Waste Policies and Legislation

Although the EU directive has been introduced to ensure appropriate WEEE recycling and resource recovery, it also causes problems and barriers to achieve this aim. For example, the basic idea of the producer responsibility should ensure effective recycling by linking product design with the End of Life stage. Conversely, by giving manufacturers the possibility by contracting a producer compliance scheme this link is broken. Consequently manufacturing and recycling are placed in two isolated industries leading to ineffective recycling. The producers have passed over their EoL - obligations to the compliance schemes and the costs to the consumers (Mayers et al. 2011; Rahimifard et al., 2009).

The purchases of electrical and electronic devices, and consequently the WEEE quantities, depend strongly on the per capita income, which is highly variable across Europe. A EU-wide mass target is therefore inappropriate and not always fair. Furthermore a mass based target leads to a focus on heavy items only. Therefore the current proposal of the European Commission of collecting annually 65% of the actual products set on the market, would lead to more collection and recycling efficiency (Mayers et al., 2011).

The categorisation of WEEE in the directive is essential for specification of collection and recycling, but it may also lead to barriers in the system. For example products not reflecting coherent recycling and treatment potential as well as material compositions are placed in the same category (e.g. cathode-ray tube and television sets). A categorisation reflecting these characteristics could lead to more effective target setting and higher recovery rates (Mayers, et al. 2011).

The reality further shows a lack of consistency across Europe. Different MS implemented the directive in different ways leading to 27 different pieces of

legislation in the EU. These national regulations vary in obligations, agreements, categorisations and definitions. For example different interpretations of key definitions like “producer” or “importer” or even “electrical and electronic equipment” have a negative impact on the policy effectiveness and lead to an absence of unified reporting (Khetriwal et al., 2011; Cahill et al., 2011; Turner and Callaghan, 2007). However, regarding the WEEE recast these problems have already been recognised by the European Union.

According to Khetriwal et al. (2011) an effective WEEE legislation should include following key issues:

- A framework for collection and recycling which is equally applicable to all European countries
- A certain flexibility, which makes it possible to adapt to the fast changes in the electrical and electronic industry (e.g. changes in already existing products or changes in product categories)
- A meaningful and useful categorisation, which reflects the recycling potential as well as the eco-efficiency of products and treatment processes
- Meaningful collection, recycling and recovery targets, which reflect eco-efficiency and enhance technological innovation and collection
- Mechanisms, which ensure balancing competition between financial performance and environmental performance
- Low administrative burdens for implementation
- Clear and sufficient penalties for non-compliance as well as clear responsibilities and information dissemination among stakeholders
- Facilitating harmonization with existing national and international laws

4.2 Production

The first stages in the life cycle of a product have crucial impacts on its last stages. This is to say that an appropriate design in a way material can be recovered and reprocessed efficiently determines its recycling potential. For an effective recycling a management approach, which addresses the whole product life cycle (product life cycle management), is necessary (Luttropp and Johansson, 2010). Therefore, cooperation between manufactures and recyclers is essential. The reality shows that most of the producers have passed over their obligations to a PCS. By giving away these responsibilities, producers do not have any incentives to improve recycling oriented product design or cooperate with recyclers (Rahimifard et al., 2009).

For a closed loop recycling system a functioning internal supply chain is needed. Therefore, again, a connection between the manufacturers and the recyclers is very important. However, due to the same reasons as mentioned above, an integrate approach within the vertical supply chain for the use of recycled material is missing to close the loop (Goosey, 2009).

Furthermore the manufacturers are mostly located far away from their markets. This makes it difficult and expensive for them to run a proper take-back scheme and also feel responsible for the waste (Goosey, 2009). Since most products are made for a global market, local recycling requirement rarely are being considered at manufacturing stage. According to Luttropp et al. (2010) recycling information placed on the product in a standardized and simple matter could lead to a more efficient material recovery. It would reduce complexity since it would be more clearly in the treatment stage what material to recover and where it can be found. Therefore a higher recycling efficiency can be reached with good product labelling.

4.3 Collection

The efficiency of a collection system consists of two main factors: the consumer's behaviour and the collection infrastructure and system itself. According to Salhofer and Isaac (2002) a good recycling system does not require only a sustainable technical infrastructure but also motivation of the users and thereby good public relations. Raising the knowledge and awareness of recycling is cost intensive and cannot be done from one day to another. However, it is fundamental to run a recycling system and prevent barriers, especially in WEEE recycling, which is comparatively a complex system. If a collection system lacks of public engagement it will operate unsuccessfully. According to WRAP (2008) four different types of people's barriers to recycling exist:

1. **Situational barriers** such as lack of space for storage, lack of time to get to the site, unreliable collection or not having adequate containers.
2. **Behavioural barriers**: having other priorities, difficulties in establishing routine for sorting and collecting waste, not having system for recycling at home, habits and routines.
3. **Knowledge based barrier** due to a lack of understanding of the basic scheme and the idea of recycling, lack of awareness.
4. **Attitude and perception based barrier**: such as not accepting that recycling bears an environmental or other benefit, not getting a personal motivation to recycle.

Regarding the infrastructure, collection systems require reasonable distances to collection points, adequate capacity and adequate technical requirements (Sahlhofer and Issac, 2002). If a collection system does not operate enough collection points and the consumer has a long way to travel to recycle his discarded equipment, a relatively low collection rate will be achieved. Therefore, the amount of individual effort directly linked to recycling shows to be one of the most important barrier. A convenient, user-friendly system yields therefore much higher recycling rates (e.g. kerbside collection), but is also very cost

intensive. The barrier for such a collection infrastructure is the question of who should carry these costs. If the costs would be passed over to consumers, the system would not be accepted leading to illegal waste dumping.

WEEE collection systems are complex and not always clear to the consumer, e.g. many don't know that they can bring it back to the retailer when purchasing a new, similar product. Especially regarding small household WEEE a comparatively high amount is still found in the residual household waste. According to Melissen (2006) consumers are very persistent in their habit of discarding small WEEE in their refused bag due to its size and the "convenience". To overcome this barriers public communications have to be addressed much more towards the consumer's behaviour regarding small WEEE disposal.

Retailers have a good position to collect WEEE, since they are located directly on the market (Goosey, 2009). However, the barriers for a strong take-back network are that they would need to carry all the collection cost, provide collection facilities and storage space

Illegal export

Illegal export is a big barrier in a closed-loop recycling system. It does not only mean loss of valuable material and metals for the economy but also non-compliant treatment and disposal in Central and Eastern Europe or in a non-OECD country.

According to Luttropp and Johansson (2008) the export of WEEE is up to 10 times cheaper than its treatment in the EU. Consequently European operators claim that they are running under capacity since a considerable amount is not being treated in the countries of collection. Illegal export is caused by leakages in the official systems. For example in the UK local authorities can sell their collected electrical and electronic goods onto third parties for reuse. Though not being legitimate recyclers, companies claim to be an environmental friendly waste company. Even registered ones are involved in illegal activities. Local

authorities should therefore reconsider whom they sell their equipment for reuse and also take more responsibility on what is happening to it after being “out of their hands”. Furthermore the system would need a stricter control system of waste management companies and exporters as well as notification and labelling of containers with WEEE being shipped out of the countries (BBC Panorama, 2011; letsrecycle, 2011e).

In Austria and other Central European countries, the export to Central and Eastern Europe is an important barrier to recycling. One of the main problems regarding this issue is where to draw the line for the equipment between being still a product or already waste. If a household is giving any equipment to an informal waste collector, it is according to the law not handling WEEE waste. But if it has not been given to the waste collector, the household would probably have brought it to a municipal collection point. As soon as the waste is handed over to a collection point it is property of the waste collection authority and declared as waste. The challenge for these systems to overcome this barrier is to make this informal waste management sector official (for further reading go to: www.transwaste.eu).

4.4 Processing and treatment

The barriers associated with WEEE processing and treatment are often linked to limited knowledge and the complex, heterogeneous material compositions. WEEE recycling requires appropriate processes, which are time intensive and costly, to recover precious material and to deal with its hazardous substances (Chancerel et al., 2009; Goosey, 2009). For these processes enough knowledge about the product, its material composition and the technology is needed.

The whole recycling process consists of different steps (see 1.3). Each step depends strongly on the accuracy of its previous steps. However, the stages in the recycling chain are often carried out isolated from each other leading to

material loss by e.g. not optimising the interface between “pre-processing” and “recovery” (Chancerel and Rotter, 2009).

The application of the most appropriate technology for different materials and products has a crucial impact on the recycling efficiency. For example shredding followed by mechanical sorting, as it is the first and most common step in WEEE recycling, implies losses of precious metals. The highest recovery rate is achieved with a manual dismantling and sorting step before any other process; in some cases shredding should be avoided completely. However, this involves understanding of the location of the precious material, which is still partially missing. More research and advanced processing technology would be needed to achieve a better material recovery, yet the limitation of the technology will never allow a 100% recovery (Chancerel and Rotter, 2009).

The quality of the material is another barrier to recycling. The heterogeneous mix leads to impure recovered material, e.g. plastic in the metal scrap. This has a negative impact on the secondary raw material prices and recycling is therefore not always economically feasible. Nevertheless, according to Goosey (2009) the problem is that especially in the UK not much emphasis is given to the introduction of new and efficient WEEE recycling and recovery processes that would have an impact to high quality recycled material. The material recovery quality is directly linked to recycling costs: better technologies lead to better material, hence to higher costs, what again is a major barrier in WEEE recycling.

In order to achieve an effective resource recovery and recycling the characteristics of the recycling process should be (Chancerel and Rotter, 2009):

- Quantification of valuable and hazardous substances of the product
- Consideration of the technical characteristic of the process and the whole process chain
- Identification of the heterogeneity of the material

Therefore barriers in the system arise by having to provide as much information as needed about the product and best technology at the least possible costs.

4.5 Economy and Market

WEEE recycling is very cost intensive and not always economically reasonable. Costs, and the question of who should bear them, are major barriers in the whole recycling system and at the end, in most of the cases, these costs are transferred to the consumers.

Before the WEEE directive, recycling was only driven by the value of its recovered metals. Yet, this value is not only a driver, but also a barrier. Still, a wide range of electrical equipment doesn't contain valuable material where an economic interest may exist for recovery or re-use. Examples for these household equipments may be toaster, kettles, radios or CD players (Goosey, 2009).

On the UK WEEE market multiple compliance schemes are collecting competitively without having strong regulations and legislations as a basis. Consequently offering their service at low cost is preferred to higher standards at best available technologies to higher cost. On the other hand where schemes are more regulated they are said to be too expensive, however the standards of recovery and recycling are much higher (letsrecycle, 2011c; letsrecycle, 2011e).

Competition in WEEE management can therefore bear advantages and disadvantages. According to Khetriwal et al. (2011) WEEE legislation should encourage competition in order to enhance improvement in treatment and recycling technologies. However, to prevent a competition strongly based on financial performance, it should include mechanisms, which ensure a balanced competition based on environmental performance.

Without a market the economy is not working properly. The secondary raw material market for WEEE is still not fully developed and leads to barriers in the

whole system. For example a market for recycled polymers is still absent in most parts of Europe. The majority of the recovered material is exported since local markets are missing. If the market is to be driven by economic incentives to recycle, the whole economy in the recycling industry still has to be changed (Goosey, 2009). A sustainable approach of a WEEE recycling market would be to recover as much material as possible at local recyclers and supply these materials to local producers. However, on such a global market as one of electronic industry, the barriers to achieve this sustainable approach are very difficult to overcome.

5 Conclusion and Recommendations

- The electronic industry is a global and fast growing business. This also affects the amount of discarded equipment and therefore the e-waste recycling industry. The major drivers of WEEE recycling are the EU WEEE directive and the value of its metal components. Due to the material compositions of both, precious metals and hazardous substance, this waste stream has to be treated differently than ordinary household waste and according to the standards in EU WEEE directive.

- The EU WEEE directive should ensure protection of human health and environment, however its implementation has not been trouble free and even the directive itself causes problems and induces barriers to recycling. These problems are found in the categorisation, target settings or even in the broad definitions of key wordings. Also basic concepts like the producer responsibility have not lead to its wanted success. By giving the producer the possibility to join compliance schemes the link between manufacturing and End-of-Life stage has been broken.

- While the UK has implemented the directive on a market-based approach with economic incentives, Austria implemented it on a regulatory approach. This is reflected in the role of local authorities. Whereas the UK WEEE regulation has not imposed direct obligations on local authorities, in Austria local authorities are obliged to set up collection points in every regional district. However, in both cases municipal collection points are the most frequently used in terms of WEEE collection. The commitment of municipalities or local authorities to WEEE collection is of crucial importance to ensure effective recycling.

On the other hand a more controlled system with regulative instruments and obligations passed over to the local authorities as it is in Austria, is more expensive to the taxpayers since public authorities have to carry higher costs.

- Producers have the possibility to join compliance schemes, which take away their responsibilities regarding collection, treatment and recycling set in the EU directive. Whereas in the UK the producer responsibility was introduced as a market based instrument, where over 40 PCS are competing on the market, in Austria only 4 PCS for WEEE were authorised by the government. Consequently, being on a competitive market the PCS offer their services at lower prices leading to lower standards of recycling. A more regulated market shows to have fewer barriers in WEEE recycling. The optimal case would be the equilibrium between incentives and penalties.

- The WEEE recast bears many new challenges for WEEE management across all stakeholders. Higher collection, recovery and recycling rates should be introduced as well as a new categorisation and a new definition of the main concepts of “producer” “importer” and “distributer”. 46% of the Austrian waste management associations, which have been questioned in a survey carried out in course of this project, do believe that Austria can reach these higher targets. However, still a lot needs to be done. All of the questioned waste management associations claim, that most measures have been or will be taken in raising public awareness and knowledge. Technical measures, which have been or will be carried out, are setting up more or larger collection containers, expending the collection network or introducing a mobile collection service.

- The first stage of a products life cycle has a major impact on its last stage. In regard of its End-of-Life stage, an appropriate product design or labelling may lead to better recycling and resource recovery. To ensure efficient recycling a whole product life cycle management approach is of crucial importance.

- WEEE recycling consists of different WEEE process stages: collection, pre-processing and end-processing or refining. Carrying them out isolated from each other lead to major barriers in the whole recycling loop. The efficiency of the whole process depends on the interaction between each stage.

- In the UK over 200 Authorised Treatment Facilities are registered with the Environment Agency. In contrast there are only 58 ATF in Austria. Whereas the processing stages are mostly carried out inside the countries, the recovered material or components, especially in the UK, are mostly exported. Due to its heterogonous mix of material, WEEE processing has to be carried out carefully and reliable to its composition. Non-appropriate processing can lead to recycling barriers and cause material loss. Technology may not only be a barrier but also the key of efficient recycling. However, it is cost-intensive and none can ensure 100% recovery.

- The effectiveness of recycling is based on its amount collected, which is further based on the consumer's behaviour to recycle. The lack of knowledge and awareness in the public is a major barrier to recycling. Public relation and communication are therefore of crucial importance to

rise the collection rate and overcome barriers to WEEE recycling. Although recycling campaigns are costly and time intensive the case studies in both countries show that they have a positive impact on the recycling rate.

- Illegal export of electronic waste has a severe impact on the efficiency of the recycling systems. The consequences are material loss for the local economy and treatment of WEEE in non-OECD or Eastern and Central European countries below environmental and labour standards. More control as well as stricter regulations and penalties should contribute to improve efficiency of the recycling systems. Furthermore making the informal waste sector official, would help to overcome this barrier.

- The two cases studies underline two different approaches of waste management, where the EU directive is implemented in different ways. However, both of them have barriers to overcome and both of them are not working trouble free. Multiple stakeholders and actors, lead both systems to be branched and complicated. Only if all of the stakeholders in each of the stages of the product life cycle are committed to recycling, the system will work at its best. For a successful implementation of the directive, the cooperation and involvement of national and local governments, manufacturers, distributors, retailers as well as consumer is essential.

- WEEE accounts for one of the fastest growing waste streams in Europe. The market penetration of cheap electronic devices is leading to a decrease of the product lifetimes and an increase of WEEE quantities. Cheaper products do also impact material composition: easy accessible and more efficient raw material is gaining importance. However, the

material will become scarcer with increasing demand of EEE products. Therefore the future may be to design for recycling and reuse in order to avoid the loss of valuable resources, as well as, new technology innovation that may lead to better recycling. However, this does not only imply a change in the manufacturing approach, but also a change in waste management approaches and in the consumer attitude and behaviour not only regarding recycling but also consumption.

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Appendices

Appendix A

A.1 List of products that fall under the EU WEEE regulations (Directive 2002/96/EC, Annex 1B)

Categories covered by the WEEE Directive	List of products that fall under these categories
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 • Cooking • 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

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
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

	• Other products and equipment for the collection, storage, processing, presentation or • Communication of information by electronic means • User terminals and systems • Facsimile • Telex • Telephones • Pay telephones • Cordless telephones • Cellular telephones • Answering systems • Other products or equipment of transmitting sound, images or other information by • telecommunications
Consumer equipment	• Radio sets • Television sets • Video cameras • Video recorders • Hi-fi recorders • Audio amplifiers • Musical instruments • 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
Lighting equipment	• Luminaries for fluorescent lamps with the exception of luminaries 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
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
Toys, leisure and sports equipment	• Electric trains or car racing sets • Hand-held video game consoles • Video games • Computers for biking, diving, running and rowing • Sports equipment with electric or electronic components • Coin slot machines
Medical devices (with the exception of all implanted and infected products)	• Radiotherapy equipment • Cardiology • Dialysis • Pulmonary ventilators

	• Nuclear medicine • Laboratory equipment for *in-vitro* diagnosis • Analysers • Freezers • Fertilization tests • Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability
Monitoring and control instruments	• Smoke detector • Heating regulators • Thermostats • Measuring, weighing or adjusting appliances for household or laboratory equipment • Other monitoring and control instruments used in industrial installations (for example, in control panels)
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 kind of products

A.2 Recovery, Recycling and Reuse targets (regarding WEEE sent to treatment) according to the Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 7, paragraph 2

(a) for WEEE falling under **categories 1 and 10**

- the rate of recovery shall be increased to a minimum of **80 %** by an average weight per appliance, and

- component, material and substance reuse and recycling shall be increased to a minimum of **75 %** by an average weight per appliance;

(b) for WEEE falling under **categories 3 and 4**

- the rate of recovery shall be increased to a minimum of **75 %** by an average weight per appliance, and

- component, material and substance reuse and recycling shall be increased to a minimum of **65 %** by an average weight per appliance;

(c) for WEEE falling under **categories 2, 5, 6, 7 and 9**

- the rate of recovery shall be increased to a minimum of **70 %** by an average weight per appliance, and

- component, material and substance reuse and recycling shall be increased to a minimum of **50 %** by an average weight per appliance;

(d) for **gas discharge lamps,** the rate of component, material and substance reuse and recycling shall reach a minimum of **80 %** by weight of the lamps.

A.3 Questionnaire sent to the Austrian waste management associations

Die Europäische Kommission schlägt vor, die derzeitige Sammelquote der EU Elektroaltgeräte Richtlinie (4 kg pro Einwohner pro Jahr) ab 2013 auf 45% der 3 Jahre zuvor in Verkehr gebrachten Mengen an Elektro- und Elektronikgeräten zu ändern, und weiters ab 2016 auf 65% anzuheben. Das würde für Österreich eine pro Kopf Sammelmenge von 12.7 kg (2013) bzw. 18.9 kg (2016) bedeuten.

Schätzen Sie diese Sammelmenge als erreichbar ein?

☐ Ja

☐ Nein

Wenn nein, welche zwei Hindernisse sehen Sie als besonders gravierend an:

1. ……...
2. ……....

Haben Sie in Ihren Gemeinden schon Maßnahmen zur Erhöhung der Sammelmengen an Elektroaltgeräten gesetzt?

☐ Ja

☐ Nein

Wenn Ja, welche?

☐ Bewusstseinsbildung in der Bevölkerung (z.B. Infokampagnen)

☐ Beratung von Haushalten

☐ Aufstellung von größeren oder mehr Sammel-Container an bestehenden Sammelstellen

☐ Ausbau im Entsorgungsnetz; zusätzliche Sammelstellen

☐ Mobile Sammlung

☐ Andere: .....

Haben Sie vor, Maßnahmen zu setzen, um die Sammelleistungen in Ihren Gemeinden zu erhöhen?

☐ Ja

☐ Nein

Wenn Nein, aus welchen Gründen?

☐ Die derzeitige Sammelinfrastruktur kann auch größere Mengen erfassen

☐ Es wird in unseren Gemeinden genug gesammelt

☐ Finanzielle Gründe

☐ Andere: .....

Wenn Ja, welche?

☐ Bewusstseinsbildung in der Bevölkerung (z.B. Infokampagnen)

☐ Beratung von Haushalten

☐ Aufstellung von größeren oder mehr Sammel-Container an bestehenden Sammelstellen

☐ Ausbau im Entsorgungsnetz; zusätzliche Sammelstellen

☐ Mobile Sammlung

☐ Andere: .....

Erwarten Sie für das Erreichen höherer Sammelquoten insgesamt

☐ höhere Kosten

☐ gleichbleibende Kosten

☐ eine Kostensenkung durch z.B. Eigenvermarktung

A.4 Waste Electrical and Electronic Equipment, Eurostat Data 2008 (Environmental Data Centre on Waste, European Commission, 2011)

United Kingdom, 2008

Table 1: WEEE collected and treated inside the country or exported (tonnes)

	Product category	Put on the market	Collected from private households	Collected other than private households	Total collected (2)+(3)	Treated in the Member State	Treated in another Member State	Treated outside the EU
1	**Large household appliances**	696 116	245 708	247 040	492 748	n/a	n/a	n/a
2	**Small household appliances**	149 222	17 480	76	17 556	n/a	n/a	n/a
3	**IT & Telecommunication**	251 305	124 821	7 189	132 010	n/a	n/a	n/a
4	**Consumer equipment**	90 056	21 600	116	21 716	n/a	n/a	n/a
5	**Lighting equipment**	315	6	249	255	n/a	n/a	n/a
5a	**Gas discharge lamps**	15 209	576	5 009	5 585	n/a	n/a	n/a
6	**Electrical & electronic tools**	84 384	9 915	401	10 315	n/a	n/a	n/a
7	**Toys, leisure & sports equipment**	57 302	616	15	631	n/a	n/a	n/a
8	**Medical devices**	2 381	7	301	308	n/a	n/a	n/a
9	**Monitor & control instruments**	4 418	541	143	684	n/a	n/a	n/a
10	**Automatic dispensers**	12	1	2 392	2 393	n/a	n/a	n/a

Table 2: UK, WEEE recovery, recycling and reuse

	Product category	Recovery (tonnes)	Recovery rate (%)	Reuse and recycling (tonnes)	Reuse and recycling rate (%)	Reused as whole applicance (tonnes)
1	**Large household appliances**	198 104	40	194 043	39	9 621
2	**Small household appliances**	14 309	82	13 929	79	147
3	**IT & Telecommunication**	102 586	78	100 302	76	9 504
4	**Consumer equipment**	16 622	77	16 254	75	1 775
5	**Lighting equipment**	178	72	164	66	0
5a	**Gas discharge lamps**	n/a	n/a	4 999	89	4
6	**Electrical & electronic tools**	8 215	80	7 893	76	505
7	**Toys, leisure & sports equipment**	429	68	420	66	82
8	**Medical devices**	247	80	180	58	7
9	**Monitor & control instruments**	548	80	534	78	8
10	**Automatic dispensers**	2 091	87	1 894	79	18

Table 3: UK, WEEE collected and treated inside the country or exported (kg per capita)

	Product category	Put on the market	Collected from private households	Collected other than private households	Total collected (2)+(3)	Treated in the Member State	Treated in another Member State	Treated outside the EU
1	**Large household appliances**	11,34	4,00	4,02	8,03	n/a	n/a	n/a
2	**Small household appliances**	2,43	0,28	0,00	0,29	n/a	n/a	n/a
3	**IT & Telecommunication**	4,09	2,03	0,12	2,15	n/a	n/a	n/a
4	**Consumer equipment**	1,47	0,35	0,00	0,35	n/a	n/a	n/a
5	**Lighting equipment**	0,01	0,00	0,00	0,00	n/a	n/a	n/a
5a	**Gas discharge lamps**	0,25	0,01	0,08	0,09	n/a	n/a	n/a
6	**Electrical & electronic tools**	1,37	0,16	0,01	0,17	n/a	n/a	n/a
7	**Toys, leisure & sports equipment**	0,93	0,01	0,00	0,01	n/a	n/a	n/a
8	**Medical devices**	0,04	0,00	0,00	0,01	n/a	n/a	n/a
9	**Monitor & control instruments**	0,07	0,01	0,00	0,01	n/a	n/a	n/a
10	**Automatic dispensers**	0,00	0,00	0,04	0,04	n/a	n/a	n/a

Table 4: UK, WEEE recovery, recycling and reuse (kg per capita)

	Product category	Recovery (kg per capita)	Recovery rate (%)	Reuse and recycling (kg per capita)	Reuse and recycling rate (%)	Reused as whole applicance (kg per capita)
1	**Large household appliances**	3,23	40	3,16	39	0,16
2	**Small household appliances**	0,23	82	0,23	79	0,00
3	**IT & Telecommunication**	1,67	78	1,63	76	0,15
4	**Consumer equipment**	0,27	77	0,26	75	0,03
5	**Lighting equipment**	0,00	72	0,00	66	0,00
5a	**Gas discharge lamps**	n/a	n/a	0,08	89	0,00
6	**Electrical & electronic tools**	0,13	80	0,13	76	0,01
7	**Toys, leisure & sports equipment**	0,01	68	0,01	66	0,00
8	**Medical devices**	0,00	80	0,00	58	0,00
9	**Monitor & control instruments**	0,01	80	0,01	78	0,00

Austria, 2008

Table 5: WEEE collected and treated inside the country or exported (tonnes)

	Product category	Put on the market	Collected from private households	Collected other than private households	Total collected (2)+(3)	Treated in the Member State	Treated in another Member State	Treated outside the EU
1	**Large household appliances**	79 411	34 484	442	34 926	34 718	208	0
2	**Small household appliances**	16 808	5 938	2	5 940	5 873	67	0
3	**IT & Telecommunication**	29 988	14 480	863	15 343	15 028	315	0
4	**Consumer equipment**	27 428	14 234	0	14 234	13 945	289	0
5	**Lighting equipment**	1 134	962	0	962	951	11	0
5a	**Gas discharge lamps**	1 914	937	29	966	965	1	0
6	**Electrical & electronic tools**	6 465	1 801	4	1 806	1 787	19	0
7	**Toys, leisure & sports equipment**	2 596	62	0	62	62	1	0
8	**Medical devices**	1 893	152	61	213	207	6	0
9	**Monitor & control instruments**	2 874	157	0	157	155	2	0
10	**Automatic dispensers**	1 156	0	146	146	144	2	0

Table 6: Austria, WEEE recovery, recycling and reuse

	Product category	Recovery (tonnes)	Recovery rate (%)	Reuse and recycling (tonnes)	Reuse and recycling rate (%)	Reused as whole applicance (tonnes)
1	**Large household appliances**	30 579	89	28 984	84	620
2	**Small household appliances**	5 026	85	4 281	73	36
3	**IT & Telecommunication**	13 397	89	11 624	77	269
4	**Consumer equipment**	12 807	92	11 358	81	278
5	**Lighting equipment**	814	85	688	72	4
5a	**Gas discharge lamps**	n/a	n/a	891	92	0
6	**Electrical & electronic tools**	1 526	85	1 332	75	21
7	**Toys, leisure & sports equipment**	53	85	45	73	0
8	**Medical devices**	179	86	149	72	5
9	**Monitor & control instruments**	135	86	115	74	1
10	**Automatic dispensers**	134	93	108	75	2

Table 7: Austria, WEEE collected and treated inside the country or exported (kg per capita)

	Product category	Put on the market	Collected from private households	Collected other than private households	Total collected (2)+(3)	Treated in the Member State	Treated in another Member State	Treated outside the EU
1	**Large household appliances**	9,53	4,14	0,05	4,19	4,16	0,02	0,00
2	**Small household appliances**	2,02	0,71	0,00	0,71	0,70	0,01	0,00
3	**IT & Telecommunication**	3,60	1,74	0,10	1,84	1,80	0,04	0,00
4	**Consumer equipment**	3,29	1,71	0,00	1,71	1,67	0,03	0,00
5	**Lighting equipment**	0,14	0,12	0,00	0,12	0,11	0,00	0,00
5a	**Gas discharge lamps**	0,23	0,11	0,00	0,12	0,12	0,00	0,00
6	**Electrical & electronic tools**	0,78	0,22	0,00	0,22	0,21	0,00	0,00
7	**Toys, leisure & sports equipment**	0,31	0,01	0,00	0,01	0,01	0,00	0,00
8	**Medical devices**	0,23	0,02	0,01	0,03	0,02	0,00	0,00
9	**Monitor & control instruments**	0,34	0,02	0,00	0,02	0,02	0,00	0,00
10	**Automatic dispensers**	0,14	0,00	0,02	0,02	0,02	0,00	0,00

Table 8: Austria, WEEE recovery, recycling and reuse (kg per capita)

	Product category	Recovery (kg per capita)	Reuse and recycling (kg per capita)	Reused as whole applicance (kg per capita)	Recovery (kg per capita)	Reuse and recycling (kg per capita)
1	**Large household appliances**	3,67	89	3,48	84	0,07
2	**Small household appliances**	0,60	85	0,51	73	0,00
3	**IT & Telecommunication**	1,61	89	1,39	77	0,03
4	**Consumer equipment**	1,54	92	1,36	81	0,03
5	**Lighting equipment**	0,10	85	0,08	72	0,00
5a	**Gas discharge lamps**	n/a	n/a	0,11	92	0,00
6	**Electrical & electronic tools**	0,18	85	0,16	75	0,00
7	**Toys, leisure & sports equipment**	0,01	85	0,01	73	0,00
8	**Medical devices**	0,02	86	0,02	72	0,00
9	**Monitor & control instruments**	0,02	86	0,01	74	0,00
10	**Automatic dispensers**	0,02	93	0,01	75	0,00