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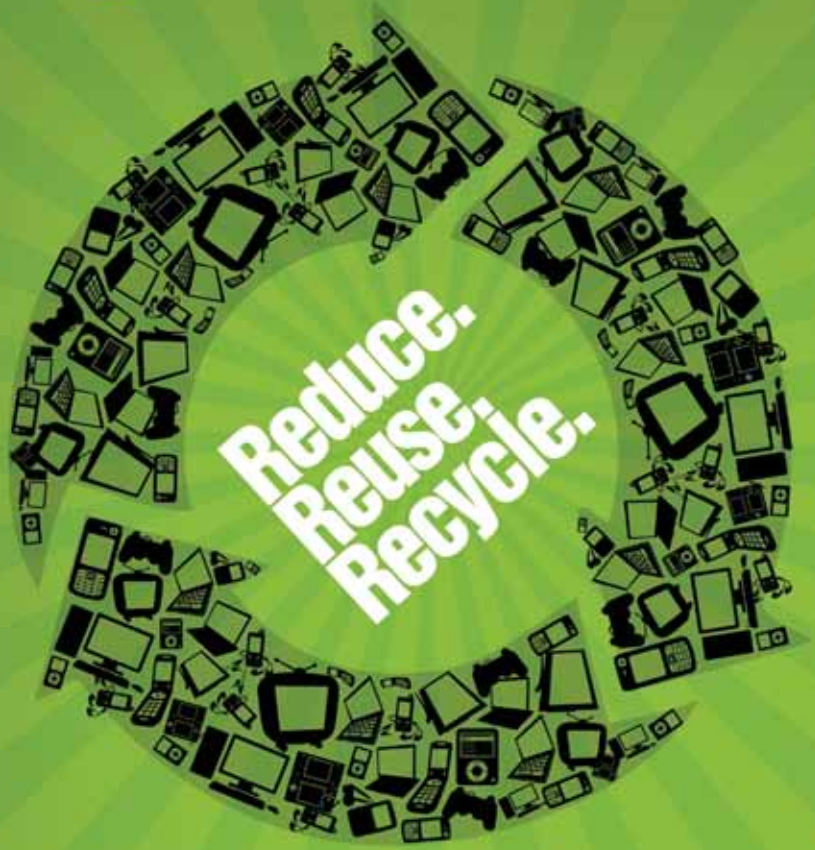

ELECTRONICS AND E-WASTE

A GUIDE FOR MANAGEMENT

balkan e-waste management advocacy network

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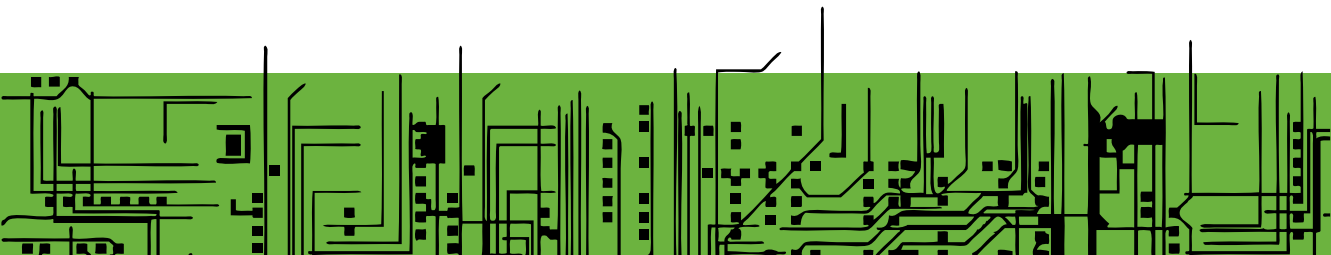

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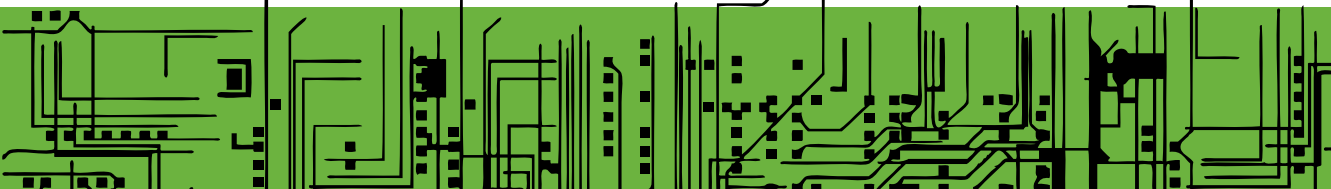


FOREWORD

Waste electrical and electronic equipment (WEEE), or 'e-waste', presents a growing challenge for governments the world over. Some 50 million tonnes of e-waste are generated globally each year,[1] with little indication that waste generation will slow any time soon. Also, electronics manufacture is materials- and energy-intensive, with significant environmental and social impact up and down the product chain.

E-waste is a complex mix of hazardous and non-hazardous waste; it also contains valuable materials which should be recovered, a process that can run at a net loss. Thus, conventional product and waste policies and approaches cannot be simply applied to electronics. Rather, e-waste requires specialised segregation and treatment, with a funding mechanism to ensure safe management is possible over the long term. There also needs to be a way to minimise waste generation, in the first place.

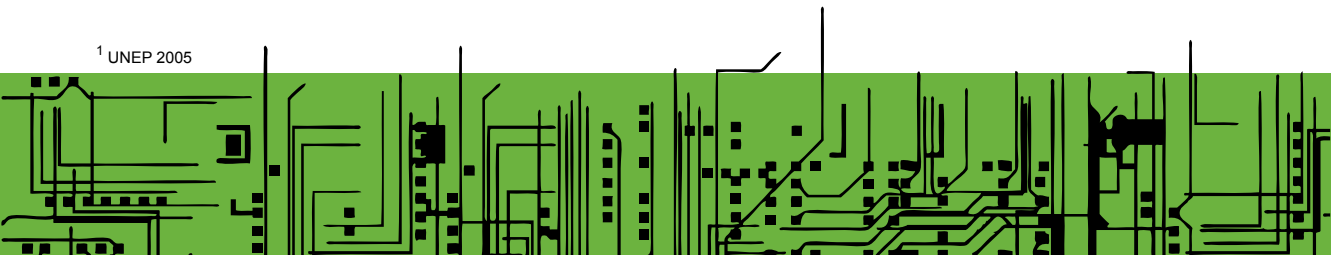
Policies and systems set up Europe (for instance, those set up under the WEEE Directive, and those in Switzerland in Norway) and elsewhere show that safe and environmentally sound management of e-waste is possible. However, some countries are yet to establish such systems. As such, we continue to see the flow of e-waste from wealthier countries with the capacity to deal with it safely and fairly, to countries without, revealing an unfair distribution of costs and benefits of the digital revolution.

This guide provides policy-makers and NGOs with an overview of the requirements for safe and effective e-waste management. This includes details and examples of the necessary infrastructure as well as the policy and legal frameworks used to address the e-waste challenge. Also, an overview of current policy and practice in Bulgaria is provided, with some recommendations for action. Detailed technical guidance for every step of the e-waste management chain is beyond this guide's scope; sources of more specific information are thus identified throughout.

ACKNOWLEDGEMENTS

This booklet would not be possible without the support of the European Union's IPA 2008 Programme of the Civil Society Facility. Also, thanks are due to generous folk that gave their time responding to requests for information and advice, including Daniel Ott, Jaco Huismann, Christopher Smith, Hackney Council/ DHL Envirosolutions, Silje Johannessen, Margaret Bates, Ulf Gilberg, Søren Freil, Christof Delatter, Jeff Cooper, Sara Norbrand, Sepp Eisenriegler, Thorsten Brunzema and Lars Eklund.

[1] UNEP 2005



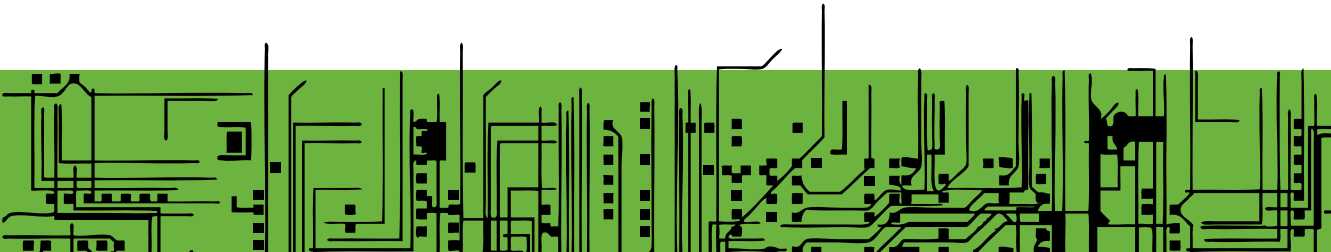
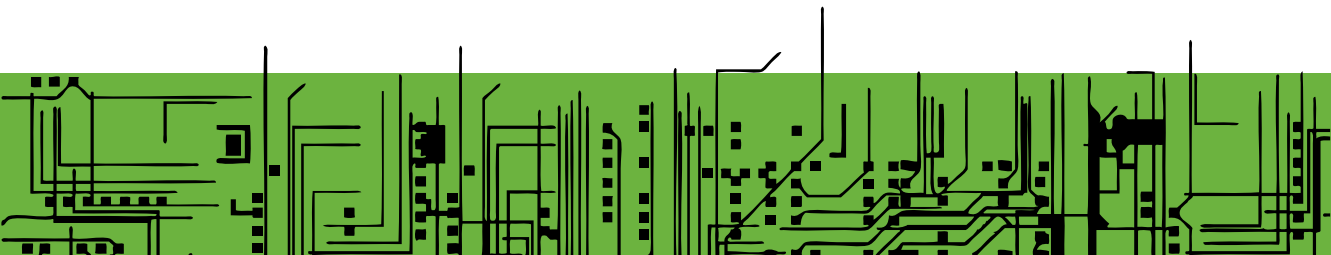


TABLE OF CONTENTS



INTRODUCTION: WHAT IS E-WASTE?

'E-waste' (or WEEE – waste electrical and electronic equipment) is a generic term used to describe various old, end-of-life or discarded appliances that contain electrically powered components.[2] This covers everything from household appliances such as refrigerators and toasters, to ICT equipment like laptops and smartphones, consumer goods like televisions, radios and mp3 players, to tools like electric drills and sewing machines – the list goes on. [3]

WHAT IS THE PROBLEM WITH E-WASTE?

Electronics have unique characteristics that make their production and consumption a source of high environmental impact, and that make them problematic and challenging – but also a source of profit – as waste.

Firstly, global e-waste quantities are increasing rapidly, a trend expected to continue unabated for some time due to the emergence of new technologies and affordable electronics.[4] Rapid product innovation coupled with limited incentives for design that would increase opportunities for repair or upgrade, mean our gadgets are quickly obsolete and discarded. [5]

By 2008 the billionth PC was installed, a figure that could double by 2014. [6]

Secondly, electronics contain many toxic substances, making e-waste itself toxic. The complex composition of electronics incorporates many materials, some of them hazardous and not easily handled when the product becomes waste. This is burdening local authorities (and so taxpayers) with the extra costs of managing a toxic and difficult-to-recycle waste stream.[7]

Brominated flame retardants, heavy metals (such as lead, mercury and arsenic), and various other substances in e-waste can seriously harm human health and the environment if not managed carefully. [8]

[2] Empa 2009
[3] A commonly-used technical definition of products covered is provided in the EU's WEEE Directive: '"electrical and electronic equipment" or "EEE" means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex IA and designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current'. Annex IA provides 10 product categories covered by the Directive
[4] Ogondo et al. 2011: 728
[5] Grossman 2010
[6] Reuters 2008
[7] ACR 2003: 17
[8] Widmer et al. 2005 and ETBC 2009

Thirdly, electronics contain many valuable and increasingly scarce materials. In a PC, these include iron, aluminium, copper, lead, nickel, tin, gold, silver, and platinum. This makes e-waste recycling a potential source of profit. Also, recovery of valuable metals and other materials in electronics can alleviate the need for mining of virgin materials. [9]

More gold could be recovered from a tonne of used circuit boards than could be extracted from 17 tonnes of gold ore [10]

Finally, most e-waste is managed badly, meaning communities and the environment pay the costs for electronics producers' toxic, wasteful design. For instance, much ends up in landfill, where it can cause leaching of hazardous materials, mercury vaporisation and fires, which leads to atmospheric pollution and toxic ash residues.[11] There is also an illegal flow of e-waste from wealthier nations to developing countries. Absent or poorly enforced environmental and worker safety legislation allow unscrupulous waste traders to exploit the lower labour costs in developing countries, and maximise the profit to be gained from materials recovery. However, due to the toxic content in electronics, rudimentary recovery methods pose great risks to the workers – some of whom are children – and the environment. [12]

Of the 50 million tons of e-waste generated worldwide in 2009, only 13% was recycled [13]

E-waste is a very different kind of waste to traditional municipal wastes. It is a complex mixture of hazardous and non-hazardous waste, which contains items of economic value which should be recovered.[14] However, e-waste recycling can run at a net loss, largely due to the difficulty of separating materials in complex products.[15] Therefore, conventional waste management policies cannot be simply applied to e-waste.[16]

Rather, e-waste requires specialised segregation, collection, transport, treatment and disposal to avoid the release of harmful substances, and to efficiently recover valuable raw materials. It also requires a funding mechanism to ensure safe management is possible over the long term, so that communities and the environment are not paying the costs for electronics manufacturers' toxic, wasteful design.

[9] For more information about valuable materials in electronics, see www.ewasteguide.info.
[10] Grossman 2010: 4
[11] ACRR 2003
[12] See e.g. Greenpeace 2008
[13] BBC 2010
[14] For an outline of the material composition of common categories of e-waste, including lists of hazardous and valuable materials contained, see www.ewasteguide.info.
[15] StEP 2009
[16] Khetriwal et al. 2009

OBJECTIVES AND SCOPE OF THIS GUIDE

This guide provides policy-makers and NGOs campaigning for greener electronics with an overview of the requirements for safe and effective e-waste management. This includes details of the necessary infrastructure as well as the policy and regulatory frameworks that have been used, to address the growing e-waste challenge.

In addition to the general principles, case studies of various approaches to e-waste management are provided. Also, an overview of the current policies and practices for e-waste management in Bulgaria is provided, with some recommendations for action.

Detailed technical guidance for each step of the e-waste chain is out of this guide's scope. Therefore, sources of more specific information and guidance for those designing systems are identified throughout the guide.

MANAGING E-WASTE

It is possible to manage e-waste in an environmentally sound manner (Box 1). To avoid or mitigate problems associated with e-waste, equipment should be carefully managed through a chain of steps (Figure 1). [17]

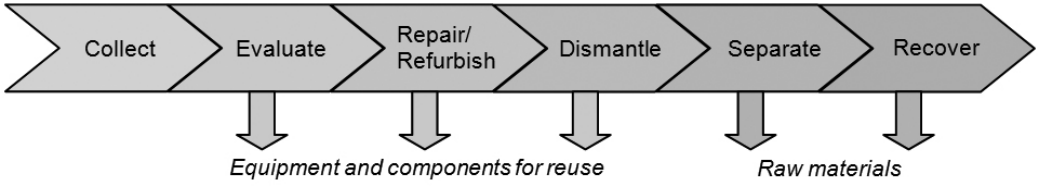


Figure 1. E-waste management chain (SOURCE: PACE 2011)

This covers numerous processes, involving a wide range of stakeholders, including producers and importers, retailers, consumers, collectors, scrap dealers, disassemblers and recyclers. In many developing countries, numerous stakeholders are in an unorganised or informal sector.[18]

[17] PACE 2011
[18] UNEP 2007: 20

With so many stakeholders and processes involved in e-waste management, assigning responsibilities and coordinating and educating actors will be vital to the system's success. Also, given the potential for the process to run at a net loss, a funding mechanism will be vital to ensure system sustainability.

Box 1. Environmentally sound management of wastes

According to the OECD, environmentally sound management (ESM) is:

a "scheme for ensuring that wastes and scrap materials are managed in a manner that will save natural resources, and protect human health and the environment against adverse effects that may result from such wastes and materials"[19] (OECD 2007: 9)

According to the European Commission, this involves the following principles:

- No waste treatment/disposal without permit
- Application of treatment standards to protect health and environment
- Proper classification, record keeping and segregation of hazardous wastes
- Inspections by competent authorities, with efficient measures and penalties against uncontrolled waste disposal
- 'Polluter pays principle': the waste generator pays for safe management

ESM thus requires adequate enforcement authorities (staff, qualifications, competences) and sufficient waste installation capacities and collection schemes.[20] The general principle of ESM underlies the EU's Waste Framework Directive (1975) and the Hazardous Waste Directive (1991). For instance, these directives include environmental protection principles, the waste hierarchy (BOX 3), and permitting and inspection requirements on waste operators. Other EU Directives, including the Directive on Waste Electrical and Electronic Equipment (WEEE) (2002/96/EC and 2002/95/EC), contribute to ESM. [21]

E-waste management systems – or take-back systems – attempt to:

- Ensure e-waste is processed in an environmentally sound and socially responsible manner
- Recover valuable materials from equipment (and so avoid the environmental burden of producing virgin materials)
- Avoid harmful e-waste disposal, such as landfill or incineration
- Motivate electronics producers to design their products so that they have fewer toxic materials, are easier to repair and recycle, and so on
- Create an efficient and sustainable means of managing e-waste (this includes the creation of eco-efficient and sustainable businesses) [22]

[19] OECD 2007: 9
[20] European Commission 2010
[21] OECD 2007: 18-19
[22] StEP 2009: 6.

The following sections give an overview of the key components of an e-waste management system, as well as the various polices, financial and legal instruments needed to manage it safely and effectively over the long term.

Assessing existing practices in and capacity for e-waste management
An assessment of existing e-waste management policies and practices – including identification and quantification of the problem and the capacity of any existing (formal and/or informal) system – can serve as a foundation for planning and implementing a formalised system. [23] Guidance on how to proceed can be found at:

- UNEP 2007. *E-waste volume I: Inventory assessment manual.*
- UNEP 2007. *E-waste volume II: E-waste management manual.*

WHAT ARE THE COMPONENTS OF AN E-WASTE MANAGEMENT SYSTEM?

E-waste management systems – or 'take-back' systems – incorporate ***system management, collection and processing*** – all encompassed and enabled by the ***financing scheme***[24] (see Figure 2).

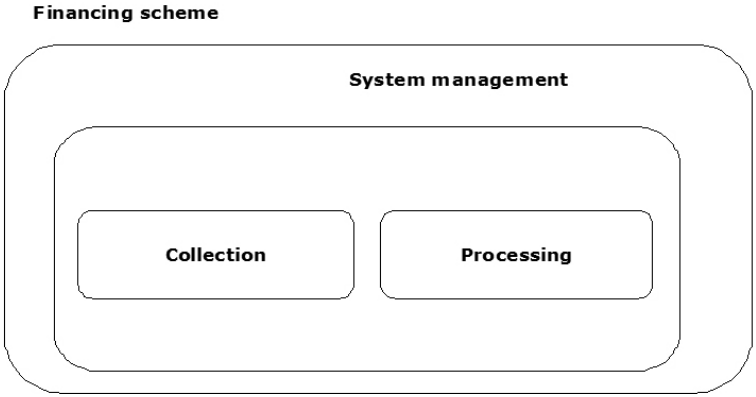


Figure 2. Main functions of a take-back system (SOURCE: StEP 2009)

[23] UNEP 2007: 21
[24] StEP 2009

COLLECTION

Efficient collection is vital to the success of an e-waste management system as it:

- Allows for more efficient recycling
- Keeps valuable components and materials in the economy
- Enables safe disposal of harmful components and materials in ways that prevent risks to human health and the environment [25]

There are numerous modes and possibilities for collection; typical mechanisms are provided in Table 1. The main channels are through municipalities, retailers, or producers' own take-back systems. For many non-OECD countries without an established national system, informal collection becomes more important. [26]

	Stakeholder			
Mechanism	Government *E.g. municipal or state department responsible for collecting waste*	Retail *Sellers of electronics*	Commercial *Usually electronics recyclers, but may be generic waste collectors*	OEM *Manufacturers of electronics*
Permanent drop-off location *Note: Must be capable of safely storing e-waste, since recyclers will rarely occur on a daily basis*	Often co-located with other hazardous waste drop-off sites. Often organised at municipality level, where consumers can leave e-waste at designated sites. Usually free for households; businesses may need to pay a fee	Located at retail outlet. Consumers take back e-waste to outlets that sell similar products. This may be on the basis of new purchase, or retailer may take back any similar product, regardless of purchase of new product	Located at entity (e.g. a recycler that accepts e-waste from the household or business that generates it, usually by drop-off at the recycling facility)	Location created in partnership with one of other three stakeholders. If not at a municipal site or retailers' facilities, specially-created sites or centres (e.g. sorting centres) controlled by producer groups or a third party
Special Drop-Off Event	A one- or two-day event dedicated to generators dropping off e-waste at a location affiliated with the stakeholder (usually government, retail and/or commercial). May be a temporary location (e.g. a parking lot, a school) or a permanent facility.			
Door-to-Door Pick-Up	Curbside pick-up from households, offered by some municipalities. May require payment of a fee	Retailers pick up old equipment when delivering a new appliance to a customer. Usually used for larger appliances, though a small fee may apply	Direct pick-up, particularly from other commercial entities that are generating significant e-waste volumes	Pick-up by mail or logistics company. E.g. some producers have web-based take-back, where consumers apply online to have old goods collected

[25] University of Northampton 2009
[26] UNEP 2007

In Europe, most countries that have achieved higher collection rates share the following characteristics: 1) longer experience in collecting e-waste; and, 2) engaging municipalities and to a large extent, retailers in collection activities.[27] Examples of the how collection is organised in some well-performing European countries are provided in Box 2.

Box 2. Maximising consumer convenience for greater e-waste collection

Effective and efficient WEEE recovery needs e-waste collected in sufficient quantities to allow large-scale recycling.[28] Most e-waste schemes in Europe operate around the municipal collection system, with varying levels of engagement of the retail sector. Indeed, some countries, such as Switzerland, have had great success with the retail route, due to convenience for the consumer. Municipal waste collection sites are seen as a convenient and cost effective option for e-waste, due to consumers' experience in using these sites for other wastes and the minimal requirements for upgrade of existing facilities. [29]

Exploiting existing municipal waste collection systems

Some EU countries have schemes that use the municipal waste collection system almost exclusively, and are managing to collect high volumes through this route. For instance, Sweden, one of the best performers, is collecting 16kg per inhabitant per year.

Elretur is Sweden's nationwide e-waste collection and recycling system, where:

- Local authorities manage and fund manned collection points (usually a recycling station), where householders may leave their e-waste without charge. They also provide information to house holds about the system and its proper use
- El-Kresten, an organisation representing electronics producers, manages and funds the transport of e-waste to facilities for environmentally sound pre-treatment and recycling, which it also pays for

The system, which comprises some 1000 recycling centres around the country, is convenient for householders, as they can leave their e-waste at the same collection points as their other waste. Most households use this method, which in some municipalities is complemented by curb-side collection. In some places, collection is available in stores, and through companies' bulky waste rooms at companies.[30]

[27] ETC/SCP 2011: 14
[28] ACRR 2003: 17
[29] UNEP 2007. However, some municipalities in the EU have expressed concern that they are not being adequately compensated for maintaining facilities, the costs of which can be high. See e.g. RREUSE-ACRR comments on the WEEE Directive recast: http://bit.ly/RREUSE-ACRR.
[30] Elretur 2009

Suggested reasons for the success of Sweden's system include long experience in collecting e-waste (they implemented WEEE-related legislation in 2001, which had buy-in by stakeholders across multiple sectors), as well as a well-established recycling 'culture'; Swedish households have a high awareness of and participation in waste sorting. [31] Nevertheless, in Sweden, as with other EU countries, the collection of small WEEE has proven a challenge[32] and so it is trialling various collection projects. One of these is "The Collector", special bins that are located in stores and that allow the public to hand in light bulbs, batteries and smaller e-waste items. [33]

Similar trials are being conducted by other EU countries to try and increase the amount of small WEEE being collected through the municipal collection systems. For instance, in the UK the London Borough of Hackney, with DHL Envirosolutions, has recently introduced small WEEE recycling banks at 10 sites throughout the borough.[34] These are secure containers into which householders can deposit items such as clocks, hairdryers, phones, small tools and any other small electrical appliances that can fit into the bank. Larger household appliances like TVs, washing machines and fridges are not meant to be left next to the banks, but recycled via the council's bulky waste service. Early indications are that the system is working well and that residents are not leaving their large appliances next to the banks. DHL Envirosolutions has established more than 70 such banks in councils around the UK, with at least 20 more planned for the near future.[35]

Engaging retailers in collection

Numerous European schemes encourage retailer participation in collection, and some have achieved high levels of collection through retail chains.[36] For instance, Switzerland has an e-waste take-back system that has been operating for more than a decade, and that has had success using the retail route for collection.

Under the Swiss e-waste ordinance, consumers must return discarded appliances to retailers or designated collection facilities (whichever is most convenient to them). Retailers have a legal obligation to take WEEE from consumers in the same product categories that they have on sale, irrespective of whether the original product was sold by them, or whether the consumer purchases a similar product as replacement. The designated collection facilities take all sorts of e-waste from consumers free of charge. They are situated at convenient places like railway stations and community waste collection centres.

[31] Swedish EPA 2009
[32] UNU 2007
[33] Elretur 2009
[34] Hackney Council 2011
[35] Pers. comm., Hackney Council Waste and Recycling Officer and A. Williams from DHL Envirosolutions.
[36] UNEP 2007

Retail outlets provide a viable and in many ways ideal take back site. For instance, many retailers already have a storage and transportation logistics chain in place that can be used dually for new products and e-waste. The retail outlets' wide coverage and accessibility makes it easier for consumers to dispose of their e-waste correctly. Also, provision of the take-back service gives retailers additional opportunities to enhance customer relations. Retailers can also distinguish functional from non-functional equipment and components; this will determine which are made available for reuse and which are sent for recycling.[37] However, there is apparently little reuse in practice; this may reflect retailers' vested interest in selling new rather than second-hand goods.

The extent to which municipalities or retailers (or indeed other stakeholders) are engaged in collection will likely depend on a number of factors, including of course country context. For instance, where municipal facilities are limited in their scope and capacities, retailers, or even informal collectors, may take a more important role. Whichever scheme(s) is finally arrived at, accessibility and convenience, as well as health and safety, should be paramount. Also, responsibilities should be clearly defined to avoid any uncertainty about who takes responsibility for the collection facilities and the waste itself, which may compromise the effectiveness and efficiency of take-back systems.

An efficient collection and transportation system is one that maximises opportunities for reuse and recycling (Box 3), and that provides for the safe treatment of e-waste. Since e-waste is hazardous, it needs to collected, sorted, stored and transported under controlled conditions. This includes: avoiding damage or breakage of components that contain harmful substances; segregating equipment and components with hazardous materials; and, removing hazardous substances.[38]

Box 3. The waste hierarchy

Waste management is often conceptualised in terms of a 'waste hierarchy', which ranks the different ways in which we can manage waste in order of relative environmental benefit. This hierarchy is reflected in various legislative frameworks.

For instance, in the EU, current policy first aims to prevent waste, then to reduce its disposal through reuse, recycling and other recovery operations.[39]

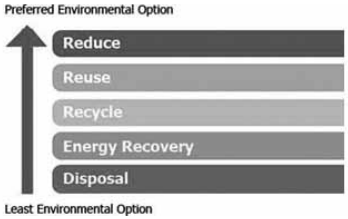


Figure 3. The waste hierarchy
(SOURCE: Zero Waste Scotland)

[37] Khetriwal et al. 2009
[38] UNEP 2007
[39] EEA 2010

For instance, the WEEE Directive identifies numerous substances, preparations and components which must be removed from any separately-collected e-waste before further treatment can occur.[40] This includes: cathode ray tubes (some PC monitors and TV screens and which contain leaded glass and phosphor coatings); ozone-depleting substances (e.g. CFCs used as refrigerants in older cooling appliances); and mercury containing components (e.g. backlights in flat screen TV and computer monitors).

Factors determining collection effectiveness and efficiency include:[41]

- Accessibility and convenience of collection facilities for consumers
- Segregation of e-waste from unsorted municipal waste
- Minimal movements of products (to reduce damage and breakage)
- Removal of hazardous substances
- Segregation of hazardous and non-hazardous e-waste and components
- Separation and safe storage of reusable appliances and components
- Provision of adequate and consistent information to users

E-waste ***collection infrastructure*** includes the collection points and storage areas. This infrastructure should be set up to enable efficient collection for treatment, recycling and data monitoring.[42] Separating out e-waste types at the collection points can assist this, and can help ensure health and safety; the following groups have been recommended, on the basis of similar treatment pathways, or need for special handling:[43]

1. Large household appliances (other than cooling appliances)
2. Cooling appliances (e.g. refrigerators, freezers)
3. Display equipment (e.g. TVs and computers) containing CRTs
4. Gas discharge lamps (e.g. fluorescent lamps)
5. All other WEEE (e.g. office equipment, small appliances etc)

Collection facilities must have the appropriate type and number of containers to store segregated e-wastes. Other features, such as impermeable surfaces and weatherproof covering for storage areas, can help avoid damage to reusable goods as well as leakage of hazardous materials.

The size, number and location of collection facilities are important considerations when establishing infrastructure. They will depend on numerous factors and will vary from country to country.

[40] See Annex II, Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)
[41] See e.g. UNEP 2007:14, DTI 2007, EU WEEE Directive
[42] UNEP 2007
[43] See e.g. Öekopol 1998, DTI 2007

These include the collection target (if present), population density, consumer behaviour, and location of recycling facilities.[44] It is important that any informal e-waste handlers that may have been operating prior to the implementation of a formal e-waste management scheme are properly integrated into the new system. To help ensure the health and safety of workers and prevent environmental pollution, any unsafe handling practices need to be addressed, such as through collection and treatment standards, and education (Box 4).

Box 4: The informal sector in e-waste collection and processing

Valuable substances in e-waste make it attractive from a materials recovery perspective, for formal operators and informal ones (e.g. scavengers and waste pickers), alike. Absent or lax health and safety controls are promoting the growth of a semi-formal or informal economy in industrialising countries. Here, a new economic sector is evolving around the collection and treatment of e-waste.[45] Even in the EU an informal recycling sector still operates, particularly in collection and rudimentary recovery of metals.[46]

While informal collection and treatment is in some countries a source of livelihood for urban and rural poor people, and other marginalised groups, it can harm workers and the local environment, due to the rudimentary handling techniques often used. There have been various attempts to avoid and mitigate these risks, by for instance educating informal recyclers about safer handling techniques, and integrating them into the formal system.

For instance, the University of Northampton (UK) and the Basel Convention Regional Coordinating Centre for Africa developed a training and education programme for informal recyclers in Nigeria. This includes modules on the threats posed by e-waste, and techniques in environmentally sound management, which can be viewed on the University's website.

In Greece, there have been attempts to integrate informal recyclers into the authorised collective alternative WEEE management system (CAMS) and at the same time to create employment opportunities for marginalised groups. Social enterprises were set up to employ Hellenic Roma (who were already engaged in informal recycling) and people with disabilities to perform sorting of WEEE into useful categories for formal recyclers. The social enterprises provide the public with more options for safe disposal of their e-waste. Also, they provide jobs for marginalised groups, who are trained in safe handling techniques. More information can be found in a report by Aravossis et al.[47]

[44] UNEP 2007
[45] Widmer et al. 2005
[46] See e.g. recent reports of extensive involvement of Roma in French e-waste management, outside of the formal system: http://bit.ly/Ecologist2010 (Accessed Oct 2010).
[47] Aravossis et al 2007

Establishing safe and efficient e-waste collection systems
Technical guidance on methods to ensure adequate and safe collection and storage that maximises possibilities for reuse and environmentally-sound recycling and other recovery can be found in the following resources:

- ACRR 2003. *The management of waste electrical and electronic equipment: a guide for Local and Regional Authorities.*
- UNEP 2007. *E-waste volume II: E-waste management manual.*
- DTI 2007. *Code of Practice for Collection of WEEE from Designated Collection Facilities (DCF). UK Department of Trade and Industry.*
- Defra 2006. *Guidance on best available treatment, recovery and recycling techniques (BATRRT) and treatment of waste electrical and electronic equipment (WEEE).*

PROCESSING

As Figure 1 shows, there are multiple steps involved in the environmentally sound processing of e-waste: i) evaluation; ii) repair/ refurbishment; iii) dismantling and pre-processing; iv) separation; and v) recovery. Any residual non-recyclable fractions are disposed of in landfills or incinerated.[48] Figure 4 outlines a process flow diagramme for used PCs that can assist to visualise this.

The first three processing steps will enable equipment and components to be reused.[49] According to the waste hierarchy (Box 3), reuse is prioritised over recycling in many waste management systems, including those set up for e-waste under the EU WEEE Directive.

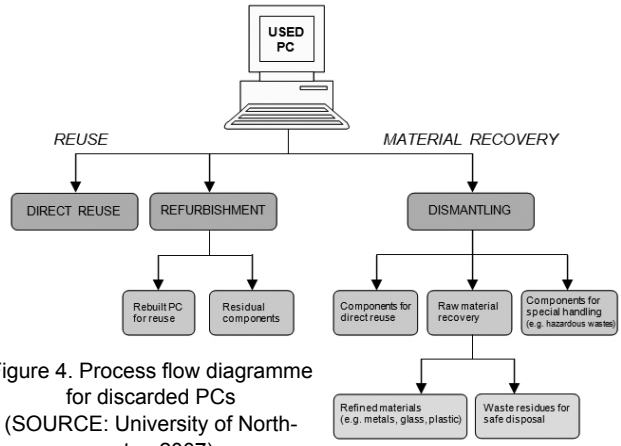


Figure 4. Process flow diagramme for discarded PCs (SOURCE: University of Northampton 2007).

[48] UNEP 2007
[49] PACE 2011

Reuse is above recycling in the waste hierarchy because it actually reduces the size of the incoming waste stream. Recycling can demand high amounts of energy and other inputs to recover the desired product fractions. It does not always recover all of the raw materials, creating residual wastes needing disposal. residual wastes needing disposal.[50] Also, even if a recycling process recovered 100% of materials from a product, this does not account for the energy and materials used and wastes generated during manufacture, which can be considerable.[51]

> ***The manufacture of a single 2g microchip can generate some 26kg of waste, some of which is highly toxic.***[52]

While ICTs and other electronics are often replaced long before the end of their productive lives, their reuse brings additional benefits, such as providing access to technologies for those unable to afford them new. The repair and reuse of electronics constitutes a new economic sector where a new kind of industry (small businesses and community groups) can develop. For instance, the remarketing of white goods, ICTs and other consumer electronics is particularly suitable for social enterprises, as they offer work, training and skills to long term-unemployed or disabled people. A thriving industry has developed in Europe. For instance, in the UK there are over 300 community organisations providing second hand goods to people in need, with electronics on the top of the list of consumer demand.[53]

Evaluation of collected e-waste is an important step, as it determines whether equipment can still be used for its original purpose, or whether it should be scrapped for material recovery. This step may be done at the initial collection site, or later, such as during decontamination or before the equipment is dismantled.[54] Items that are able to be reused must be segregated at the earliest possible opportunity, to prevent damage that may render it unusable. Evaluation will also need to happen after disassembly, to identify working parts inside non-functional equipment. Equipment that is identified as suitable for reuse may need ***refurbishment or repair.*** For example, in computing equipment, this may include replacement of hardware or software, removal and destruction of any data left by the previous user, cleaning and labelling, followed by remarketing.[55]

The success of reuse initiatives will depend on the trust that consumers have in the quality and security of second-hand equipment; this means that reuse operations will have to be professionally organised (Box 5).

[50] EPA 2009
[51] Leonard 2007
[52] Williams 2002
[53] ACRR 2003
[54] PACE 2011
[55] PACE 2011

For instance, identification of appliances for potential remarketing for reuse will require initial visual, electrical and safety tests. After any repair or refurbishment, operation tests should be used to assess the fitness of products, for instance through a high voltage test. Equipment should also undergo cosmetic cleaning to give it an attractive appearance.[56]

Box 5. Making reuse a practical reality... by professionalising the reuse sector

A number of innovative approaches have been taken in Europe to maximise the reuse of WEEE and other waste products through the professionalisation of the reuse sector. These include the creation of a clear and consistent corporate identity for reuse centres, the maximisation of brand awareness and changing perceptions of reuse.

For instance, in Belgium, the Koepelvan VlaamseKringloopcentra (KVK) has implemented a marketing strategy to increase reuse within Flanders. Foremost among this are the 40 reuse centres which are members of KVK. In addition, KVK governs the trademark 'Revisie', which is attributed to eight refurbishment centres in the region. This label helps to ensure a standardised quality and a common refurbishment procedure.

In 2002, after 10 years in operation, KVK rebranded itself as 'De Kringelwinkel' and created a quality control system for the reuse centres. This was part of new marketing strategy to consolidate brand identity (while the centres were well-known, customers were confused by the different names and appearances of the reuse shops) and improve perceptions of the quality of reused goods. The strategy, coupled with a press campaign, aimed to increase public awareness of reuse and encourage the use of these centres.

Following on from KVK's success, a similar strategy has been implemented in Austria. Repair-Network Austria (RepaNet) acts as the umbrella organisation for a network of repair enterprises which have capabilities to work with electrical and electronic equipment.

In Austria, there are a series of reuse shops within the Federal State of Upper Austria known as ReVital shops. These are subsidised by the federal government. In addition, RepaNet has used joint PR and marketing to increase awareness in Vienna, making repairing and reuse of greater interest to the public.

[56] ACRR 2003

R.U.S.Z (Reparatur- und Service-Zentrum), working with RepaNet, has initiated a series of repair and service centres within Austria's largest towns (Vienna and Graz) as well as some local authorities. These authorities have developed a guide for the public on repair, lending and second-hand equipment. The repair and service centres provide jobs for long-term unemployed people and have served to substantially increase demand for repair services. Comprehensive media coverage has increased public awareness of this scheme. As a result, R.U.S.Z now serves 6,000 customers a year and brand recognition has reached 24%. Furthermore, people now actively take pride in this service.

Making discarded electronics fit for reuse

There are a number of manuals available that provide information on how to safely and effectively make discarded electronics available for reuse. These include:

- ACRR 2003. *The management of waste electrical and electronic equipment: a guide for Local and Regional Authorities. Chapter 6: The repair and reuse of old appliances.*
- BSI 2011. Publicly Available Specification 141 *for the processing for reuse of waste and used electrical and electronic equipment. http://shop.bsigroup.com/*
- FRN 2001. *Fit for re-use: a guide to the repair, refurbishment and re-use of domestic electrical appliances.*
- *PACE 2011. Guideline on environmentally sound testing, refurbishment & repair of used computing equipment.* UNEP/Basel Convention Project 1.1.

Any equipment that cannot be reused as a whole appliance should begin to undergo the ***material recovery*** process. In order to recover materials, e-waste needs to be taken apart and directed to adequate subsequent final treatment processes. Thus the next step in e-waste processing is ***dismantling and pre-processing***, including decontamination. This involves the removal and segregation of hazardous substances for specialised treatment (e.g. capacitators,[57] CRTs, batteries and ozone-depleting substances[58]), easily-accessible components for reuse (e.g. motors, computer hard drives etc), and valuable parts for further recovery (e.g. metals, glass and plastic).[59] Decontamination and initial dismantling should be done manually prior to any further pre-treatment, as it allows for the efficient removal of hazardous parts and substances, and for components to be identified for reuse.[60] Later dismantling and pre-processing steps may be done by mechanical processes such as shredding, once hazardous parts have been removed (Box 6).

[57] These are devices that store electric charge in electrical appliances. Those in older electronics can contain harmful polychlorinated biphenyls (PCBs), carcinogens that do not break down in the environment.

[58] These include ozone-depleting chlorofluorcarbons (CFCs) used as refrigerant gases in older fridges, freezers and other cooling appliances that can damage the ozone layer if released into the atmosphere

[59] UNEP 2007

[60] ACRR 2003

For instance, the circuit boards in ICT equipment contain many precious and specialty metals. They can also contain potentially harmful lead solders and resins containing flame retardants. Manual removal of the boards will prevent the loss of precious metals as well as potential contamination that can occur when equipment is shredded without any pre-treatment.[61] Measures must be taken to protect workers performing manual dismantling from exposure to hazardous substances, such as engineered control systems and personal protective equipment (e.g. gloves, eye protection and masks). [62]

Box 6: Making e-waste safe for recycling: decontamination

Common decontamination methods for e-waste include:[63]

- De-gassing of refrigerators and other cooling appliances to remove chlorofluorocarbons (CFCs) and other ozone-depleting substances
- Manual removal of mercury-containing backlights in some models of flat screen computer monitors and TVs
- Manual removal of batteries, which can be sent to specialised facilities for the recovery of cobalt, nickel and copper
- Manual removal of CRTs, plus (manual or semi-automatic) removal of phosphor[64] coating inside the front panel of TVs or monitors

Outputs from the pre-processing step can be subject to further separation by additional manual dismantling or mechanical shredding and automated sorting. To avoid the generation of non-recyclable fractions or material loss, segregated outputs must meet the requirements of the end processors.[65]

Segregated fractions (e.g. ferrous and non-ferrous metals, glass and plastic) are next sent for final ***recycling and recovery of valuable materials.*** This involves specialised processes that require high levels of process technology as well as monitoring and worker and environmental protection.[66]

Final metals recovery occurs by smelting, in aluminium smelters, or integrated metal smelters for fractions containing copper or lead, as well as circuit boards and other fractions containing precious metals.[67] The ***plastics*** fraction tends to have less recycling outlets than the metal fractions (especially since some plastics have hazardous substances like brominated flame retardants), and so the predominant disposal route for plastics is incineration with energy recovery (and some landfill).[68]

[61] UNEP/StEP 2009
[62] PACE 2011
[63] UNEP/StEP 2009
[64] Phosphors are substances that emit light when energised by a CRTs electron beam. They will be exposed when the front panel is separated from the back funnel glass and can be rubbed off (PACE 2011).
[65] UNEP/StEP 2009
[66] PACE 2011
[67] StEP/UNEP 2009
[68] ACRR 2003

Similarly, some ***glass*** fractions are hazardous. For instance, CRT glass requires specialised treatment that may lead to secondary production of new CRT glass or other industrial applications (e.g. aggregate for the cement industry).[69]

Any dangerous materials and residual wastes that cannot be recycled should undergo ***safe disposal***.[70] For instance, shredder residues are disposed of in controlled landfill sites or sometimes incinerated. CFCs are treated thermally, while PCBs are incinerated or disposed of in underground storage.[71] Incineration can release substances like, dioxins, furans and other harmful emissions. Therefore, only non-recyclable, burnable residues should be incinerated, and only in state-of-the-art facilities. Where possible, energy should be recovered during incineration.[72]

The complete chain of e-waste collection and processing steps may be performed in many places and it can take a long time before marketable raw materials are produced. Therefore, to ensure environmentally sound, resource efficient and legally authorised treatment of e-waste, there needs to be communication and coordination up and down the management chain, since each person has responsibilities to other actors at other steps. [73]

Environmentally sound recycling and recovery of e-waste

Guidance on environmentally sound recycling and recovery of e-waste, including information about best available techniques and guidelines for treatment areas, can be found in the following:

- ACRR 2003. *The management of waste electrical and electronic equipment: a guide for Local and Regional Authorities.* Ch. 5: Pre-treatment and recycling.
- UNEP 2007. *E-waste volume II: E-waste management manual*
- Defra 2006. *Guidance on best available treatment, recovery and recycling techniques (BATRRT) and treatment of waste electrical and electronic equipment (WEEE)*
- UNEP/StEP 2009. *Recycling: from e-waste to resources*
- WEEE Directive, especially Annex III (technical requirements for facilities)

SYSTEM MANAGEMENT

In a take-back system, the ***system manager*** has the important role of co-ordinating the actions of various stakeholders and enforcing the system rules and responsibilities.[74] Activities falling under this include:

[69] StEP/UNEP 2009
[70] UNEP 2007
[71] EEA 2003
[72] PACE 2011
[73] PACE 2011
[74] StEP 2009: 8

- Organising collection and processing of e-waste
- Fee administration (e.g. registering electronics manufacturers and their sales, collecting fees, reimbursing collectors and processors)
- Setting treatment standards and distributing treatment licenses
- Ensuring compliance (e.g. inspection, monitoring and enforcement)

Management may be performed by a single public or private entity, or a combination of bodies. These could include governments, third party organisations, or electronics manufacturers themselves:

- *Government* – usually led by environment agencies and/or ministries
- *Third party organisations* – these are compliance schemes or producer responsibility organisations (PROs) that provide management and administration of a collection and take-back programme for e-waste on behalf of their members (Box 7)
- *Electronics manufacturers* – these are individual manufacturers' own take-back programmes.They are most common for commercial consumers, where electronics producers contract others to collect and treat discarded appliances, usually packaged with other services like data removal, installation and repair. Some producers may also offer free web-based take-back services for household consumers

Box 7. Managing e-waste in Europe: producer responsibility organisations

All of the e-waste systems established by EU member states, as well as some non-EU European countries, are based on the principle of extended producer responsibility. This means that electronics producers have to take financial and/or physical responsibility for their goods over the full product lifecycle, including when they become waste.

In many instances, producer responsibility organisations have been established to assist producers to meet their obligations. These are third party, usually non-profit bodies that collectively arrange collection and treatment of e-waste on behalf of their members. They may also provide other services, such as reporting and fee administration.

Some countries, like the Netherlands, Sweden, Switzerland, Belgium and Norway, have single, non-competing, national compliance schemes for electronics manufacturers in certain product categories. Others, like Germany, France and the UK, operate multiple schemes, which are then able to compete amongst each other for the best prices for their members. There are arguments for and against each arrangement.[75] For instance, single national schemes present a simpler solution and economies of scale, and drive competition between recycling and collection contracts, rather than between the schemes themselves, which can result in compliance at lowest cost, rather than best environmental outcomes.[76]

[75] See e.g. IIIEE 2006
[76] See e.g. EIA 2011

If there are multiple schemes in operation, coordination mechanisms will be vital, to ensure a level playing field and avoid selective WEEE collection by e.g. more favourable product weight and geographic area. If there is a single scheme, transparency in the allocation of treatment contracts (to avoid e.g. recycler monopolies) will be important.[77]

FINANCING SCHEME

The sustainability of an e-waste management system is dependent on the financial viability of its collection and processing arrangements.[78] Given that e-waste management costs can run at a net cost, a ***financing scheme*** is required to ensure the system can function over the long term.

System financing for e-waste in the EU and some other European countries (and in more and more countries around the world) is based on ***extended producer responsibility*** (EPR, see Box 8). This is:

…a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the product's life cycle, and especially to the take-back, recovery and final disposal of the product' [79]

Under EPR, electronics producers have *financial* responsibility for their goods if they are obliged to pay for safely treating the e-waste arising from their products. They have *physical* responsibility if they are involved in the actual organisation of a take-back system (e.g. they physically take back their goods and recycle them).

Such an approach to policy-making is useful as it is designed to be less prescriptive and more goal-oriented, incorporating incentives for industries to continuously improve their products and processes.[80] By shifting responsibility away from municipalities (i.e. taxpayers) and onto electronics producers, EPR means to incentivise them to take environmental considerations into account when designing their goods (i.e. 'ecodesign').

Box 8. Why extended *producer* responsibility?
Extended producer responsibility (EPR) is being widely-adopted in waste management strategies, particularly for products that require special handling and treatment at end-of-life on account of their hazardous content.This makes EPR well-suited to e-waste management.

[77] See IIIEE 2007 and Khetriwal 2007
[78] UNEP 2007
[79] IIIEE 2006: 2, quoting Lindqvist 2000.
[80] IIIEE 2006: 1

Growing volumes of toxic e-waste, and the difficulties involved in recycling it means that we need to look at the problem at source – at design and manufacture.

Also, electronics manufacture is a material- and energy-intensive process. For instance, ***the production of each PC requires 22 kg of toxic chemicals, 240 kg of fossil fuels and 1,500 kg of water.*** Any strategy to reduce the impacts of our electronics must necessarily also focus on manufacture; an EPR approach allows for this.

Key considerations when establishing system financing under EPR include:

- *From which point are producers responsible, and how much?* In the EU, producers are to cover the costs of collection and treatment of e-waste from designated collection points onwards. This means that in many member states, municipalities are still contributing to e-waste management, by setting up and maintaining the collection facilities
- *Which stakeholder(s) will be responsible for e-waste from goods that existed prior to implementation of the system?* In the EU, this is referred to as 'historical WEEE,' and costs are shared amongst electronics producers existing on the market when the waste arises

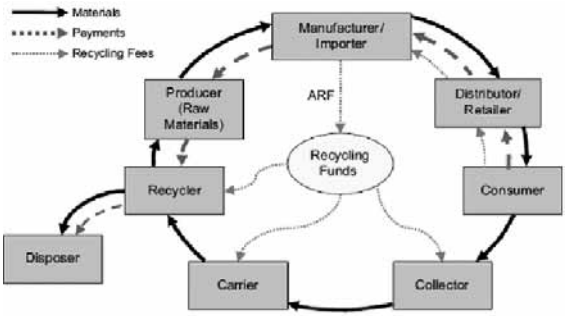


Figure 5. Flow of materials and finances in the Swiss e-waste management system (SOURCE: Khetriwal et al. 2007).

- *Which products are to be covered?* Collecting more product types adds complexity to the system but ultimately means less toxic e-waste in landfill, and less confusion for consumers and other actors
- *How to deal with e-waste from households vs. commercial consumers?* There are some differences in the logistics and contracts for household and commercial wastes, so the way responsibilities are discharged may also differ. In the EU, the financial responsibility for commercial consumers is slightly different to that for householders (i.e. they may be partly or wholly responsible for historical WEEE)
- *Which financial model should be used?* The financing model will specify the relationships amongst stakeholders, and the financial flows (Figure 5). Generic models include compliance cost (where producers pay an upfront fee and bear all management costs), visible fee (shown on sales receipt, often used for historical waste) and advanced recycling fee (paid by consumers at the point of sale)[81]

[81] StEP 2009: 11

Getting the finances right for sustainable e-waste management
Assistance on developing and implementing a financial model, including various success factors and technical guidance on calculating the model, can be found in pages 90-95 of UNEP (2007) *E-waste volume II: E-waste management manual.*

POLICIES AND LEGAL INSTRUMENTS

Policies, laws and regulations provide an institutional framework for the implementation of e-waste management.[82] They help regulate behaviour and encourage best practice in electronics design, manufacture, use, and e-waste management. They also help to define roles and assign responsibilities.

Rapid obsolescence in modern electronics is driving rapid e-waste generation. Also, toxic, complex designs make these products difficult to handle and recycle at their end-of-life, and in any case, technological change outstrips innovations in treatment and recycling technologies.[83] A preventative approach that targets the problem at source – at design and manufacture – is clearly necessary to address the growing e-waste pile.

ASSIGNING RESPONSIBILITIES IN E-WASTE MANAGEMENT

Many stakeholders are involved in the life cycle of electronics, and all will have some influence on their environmental impact. Yet, the best policies identify the most important actors and give them specific responsibilities. [84] It is electronics producers that are most able to make the changes at source (in design and manufacture) to reduce the impacts of their products.[85] This is why many countries, including those in the EU, use EPR as a policy framework for minimising the environmental impact of electronics. EPR-based systems must include mechanisms to ensure compliance and avoid free-riding, incorporate historical waste and orphan goods,[86] prevent illegal exports and poor treatment, and incentivise collection. Instruments used to achieve this include informational demands on producers, export bans, penalties for non-compliance, collection targets and treatment standards.[87] Table 2 shows some EPR policy instruments for e-waste.

[82] UNEP 2007
[83] Ogondo et al. 2011: 728
[84] EEB 2010
[85] IIIEE 2006
[86] 'Free riders' are those manufacturers that can reap the benefits of an existing EPR scheme without making a financial (or other) contribution to it; 'historical waste' refers to waste arising from products that existed on the market before the EPR system was implemented; 'orphan goods' refers to waste from producers that are no longer on the market when the product reaches its end-of-life.
[87] Widmer et al. 2005

Table 2. EPR policy instruments for e-waste (SOURCE: Adapted from IIIEE 2006).

Instrument	Examples for e-waste
Administrative instruments	• Requirement on producers/retailers to take back discarded electronics • Restrictions on hazardous substances in the manufacture of new goods e.g. the restriction on hazardous substances (RoHS) directive • Restrictions on the import/export of e-waste • Bans on the landfilling of e-waste • Fulfilment of environmentally-sound treatment standards
Informative instruments	• Requirements on electronics producers to mark/label products (to inform consumers to keep e-waste out of landfill) • Requirements on electronics producers to provide information to repairers/recyclers about their products, to ensure safe handling
Economic instruments	• Advance recycling fees or deposit-refund systems • Material/product taxes on electronics producers

Even when EPR has electronics producers with primary responsibility for the end-of-life management for their goods, there remain roles and responsibilities for other actors in the product chain. Communication and co-ordination with all actors are vitally important to the of the EPR policy and programme, as is education about roles and responsibilities. For instance, consumers' consumption and disposal behaviours are important to an e-waste management systems' success. Also, governments have a big role to play. They need to develop the necessary policies and legal frameworks, and help ensure compliance (Box 9). At the local level, governments are also likely to maintain a significant operational involvement in e-waste management. Table 3 gives an overview of key stakeholder responsibilities in an e-waste system.

Box 9. A more intelligent approach to enforcement

The United Kingdom (UK) generates over one million tonnes of e-waste each year. While the UK is meeting its targets for collection and recycling of e-waste, illegal export to non-OECD countries such as Ghana and Nigeria remains a challenge. Such a practice is in contravention of the EU Waste Shipment Regulations.

The key demands for used electronics in non-OECD countries are: 1) a legitimate desire for working used electronics whose lower cost can help bridge the digital divide; 2) a source of data for dishonest use (e.g. fraud and identity theft); and 3) crude metal recovery.

Environmental regulators in Ghana and Nigeria along with NGOs suggest that most electronics that arrive in these countries are melted down for metal recovery. Crude and unsafe techniques, such as burning, melting and dumping of residual wastes, are commonly used, at a huge cost to health and the environment. Absent or lax laws and regulations has contributed to the development of an informal recycling industry in these and various other non-OECD countries.

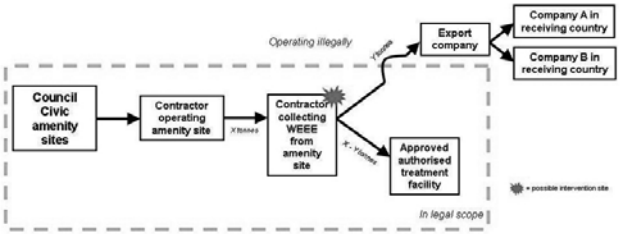


Figure 6. By gathering intelligence from multiple sources, the Environment Agency can map the e-waste (WEEE) chain and identify criminal activity and possible sites to intervene.

An illegal waste market exists in Europe for unscrupulous operators to source and charge e-waste producers for its disposal, under the guise that it is being treated legitimately in the producing country. Large volumes of e-waste can then be diverted overseas illegally for sham metal recovery. With low shipping costs, it may be up to four times cheaper to 'dispose' of e-waste in a non-OECD country than through the regulated system in the UK. This lucrative deception and perceived low risk of prosecution have resulted in a criminal fraternity engaging in illegal export. Other serious and organised crimes have been found amongst illegal waste exports as a result of Environment Agency (EA) enquiries.

With waste passing through numerous sites across the UK before final disposal or illegal export, it is often difficult to detect where the waste is leaking out of the regulated system. Detection is even more challenging when e-waste is collected at non-permitted sites that escape the EA's regulatory net.

Putting exact figures on the scale of illegal export has not been possible. Illegal waste exporters usually mislabel their cargo as something generic, such as 'household goods'. This makes it difficult to distinguish shipping containers with legitimate cargo from those full of e-waste. However, Nigerian and Ghanaian authorities suggest that over 1000 containers full of e-waste arrive in their ports from around the world each month.

The EA set about tackling this problem three years ago, via an intelligence-led approach that uses more traditional policing methods to identify preventative and enforcement measures. The EA's Securing Compliant Waste Export Project is a pro-active intelligence gathering team that only detains shipping containers for inspection once the whole picture regarding the exporter has been developed.

The project team gathers intelligence from multiple sources to prevent the shipments from occurring and to undertake enforcement action. It collaborates with other law enforcement agencies to fill intelligence gaps and 'maps out' the waste chain (Figure 6) to identify the best place to intervene.

Rather than using a random approach to detaining shipping containers, the EA has developed a much more effective and efficient methodology. This has resulted in an increase from 10% to 98% of the shipping containers that are stopped by the EA being found to be an attempted illegal export of waste. Recently an individual was convicted of attempting to export three shipping containers to a non-OECD country, with a successful prosecution by the EA leading to a fine of £12,000. The EA currently has 22 ongoing criminal investigations underway and some could be worth millions of pounds if successful prosecutions lead to the recovery of funds through the Proceeds of Crime Act.

(Source: information provided by Chris Smith at the Environment Agency – for further information on the methodology the EA undertake please contact Chris at christopher.smith@environment-agency.gov.uk)

When establishing an EPR-based system for e-waste, important elements for policy-makers to consider include:[88]

- Legal regulation. How elaborate or prescriptive is the legislation? Does it compel environmentally sound management? Does it clearly elaborate roles and responsibilities for all stakeholders?
- Producer responsibility: What level of responsibility is placed on producers vs. other stakeholders, i.e. what type(s) of responsibility, at which points, and how is this responsibility shouldered in practice? For instance, while each electronics producer may be individually responsible for its own goods, several manufacturers can come together to form a collective e-waste management system.

Some specific suggestions for policies that contribute to sound management are provided in BEWMAN's E-waste Advocacy Booklet.[89] They include: 1) banning e-waste import and export;[90] 2) banning the landfill of e-waste; 3) prioritising reuse of functional equipment by e.g. including the reuse of whole equipment in any recovery targets; 4) compelling e-waste recycling; 5) enacting producer responsibility and promoting ecodesign; and 6) enforcement – monitoring actors and punishing criminal activity.

[88] Widmer et al. 2005: 447-8

[89] Available at www.bewman.eu.

[90] Note: e-waste is distinct from used, but still functional equipment, which can still be exported under current global treaties, and indeed there are benefits to doing so (e.g. environmental benefits of reuse, social benefits from increased access to technologies). Also, end-processing of some outputs from initial e-waste recovery processes (such as printed circuit boards) can only occur in specialised treatment plants that exist in but a few countries; an e-waste export/import ban should not prohibit such outputs from being sent for final recovery processes.

To eliminate the health and environmental impacts of electronics, and to maximise the resource potential in e-waste, governments must:

1. Ban the import and export of e-waste
2. Ban the landfill and other dumping of e-waste
3. Prioritise reuse over recycling for functional equipment
4. Compel e-waste recycling
5. Enact producer responsibility to fund e-waste management and promote ecodesign (including collection targets, treatment standards, hazardous substance bans, and public education and communication)
6. Enforce it – monitor actors and punish criminal activity

For more information, see BEWMAN (2011) E-waste Advocacy Booklet

The legislative approach to electronics and e-waste undertaken by the EU is encompassed by the following three directives:[91]

1. **The WEEE Directive 2002/96/EC.** The Waste Electrical and Electronic Equipment Directive (WEEE Directive) aims to prevent waste generation and to promote reuse, recycling and recovery to reduce the amount of e-waste going to landfill. It covers 10 broad equipment categories. An annual collection target of 4kg per person applies, with specific recovery targets per product category. Priority should be given to the reuse of whole appliances and components. Producers must finance the end-of-life costs of their own goods and consumers must be able to return their WEEE free of charge. Following a 2008 review which identified key implementation issues, the Directive is undergoing a recast to improve its efficacy.

2. **The RoHS Directive 2002/95/EC**. The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) aims to restrict the use of certain hazardous substances in the manufacture of electronics, including those imported into the EU. These are four heavy metals (lead, cadmium, mercury and hexavalent chromium) and two groups of brominated flame retardants (PBBs and PBDEs).

3. **The EuP Directive 2009/125/EC**. The directive establishing a framework for the setting of ecodesign requirements for energy-using products (the EuP Directive) aims to improve the environmental performance of products throughout their life cycle through systematic integration of environmental aspects at the design phase (ecodesign). This may be via regulations, voluntary industry initiatives, or other mandatory requirements that are applied via implementing measures, developed using guidance in the Directive. Some are already adopted e.g. for PCs, TVs, and domestic lighting.

[91] More detailed information on these directives can be found in BEWMAN's E-waste Advocacy Booklet.

Key global treaties and other initiatives include the following:

• **The Basel Convention**. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal controls the export, import and disposal of hazardous wastes. The 'Basel Ban Amendment' bans all export of hazardous waste from OECD countries to non-OECD countries. The EU has ratified the Basel Convention and Ban Amendment, via the Waste Shipment Regulations 2006/1013/EC. This means that no hazardous waste – including e-waste – should be exported from the EU for treatment in non-OECD countries.

• **PACE**. The Partnership on Computing Equipment (PACE) was launched at the ninth meeting of the Conference of the Parties to the Basel Convention, 2008. It is a multi-stakeholder partnership which gives a forum for governments, industry leaders, NGOs and academia to find environmentally sound solutions to waste computing equipment. (See www.basel.int/industry/compartnership)

• **StEP (Solving the E-Waste Problem) Initiative**. StEP brings together members from various UN organisations, industry, governments, international organisations, NGOs and the science sector with the aim of establishing sustainable approaches to handling e-waste. It conducts its work via analysis, planning and pilot projects in the Task Forces: Policy, ReDesign, ReUse, ReCycle and Capacity Building. (See step-initiative.org)

Assessing existing regulations and institutional framework for e-waste
Guidance to assist policy-makers in assessing the existing regulatory and institutional frameworks for e-waste, which will help identify gaps and ways forward, can be found in:

- UNEP 2007. *E-waste volume II: E-waste management manual*
- UNEP 2011. *Ewaste Manual 3: WEEE/ E-waste "Take Back System" (In draft form at 13 May 2011)*

Table 3: Key stakeholder responsibilities in a take-back system (SOURCES: StEP 2009, OECD 2001, IIIEE 2006, others).

Stakeholder	Responsibilities
National governments	• Establish sound, efficient **policy/ legislative framework** • **awareness-raising** • establish **enforcement** mechanism to avoid free-riding and illegal exports and to incentivise collection and recovery
Producers	• **financial responsibility** – should cover all costs of end-of-life management of own goods for new products and some/all of those for historical WEEE • **organisational responsibility** –contribute to improved economies of scale and knowledge-sharing for better collection and treatment • **better product design** – e.g. design out toxics, design in more recycled content, design for longevity, recyclability etc
Producer responsibility organisations (PROs)	• **realise economies of scale** – educate consumers, make logistics efficient etc • **realise high standards** – PROs should allow member producers to collectively manage take-back of their products in ways that are more efficient than individual schemes, but to highest environmental standards. However, they should not preclude producers from establishing their own systems
Municipalities/ Local authorities	• crucial role, one that needs precise definition, as often maintain at least some responsibility e.g. in collection, infrastructure, communication, oversight etc. • *defining local authorities' relationship with producers or their PROs is vital to system functioning*
Retailers	• strategic role in product chain e.g. new for old take-back, fee collection, refund, information dissemination • **maximise collection** –provide take-back, *at least* on like-for-like basis and forward on to compliance schemes
Recyclers/ other treatment operators	• develop and **operate to best practice** – best available, environmentally and socially-sound technologies, no illegal secondary trading • **prioritise reuse** of functional equipment
Consumers	• consumption behaviours – **extend life of goods** (e.g. through refurbishment, reuse), only purchase new from greener manufacturers • disposal behaviours – **maximise collection** – hand in old products (and only to reputable operators) • *communication/education programme for consumers is essential to their engagement with and the success of the take-back system*
Civil society/ NGOs	• **education and awareness-raising** amongst decision-makers, producers general public and so on • **mobilisation** of various actors in the product chain • **watchdog/ monitoring** role where government systems are lacking or dysfunctional

GLOSSARY

Basel Convention. Global treaty introduced in 1989 to control the trade in toxic waste. A later amendment bans the export of hazardous wastes from OECD to non-OECD countries.

CRT (cathode ray tube). Used in older-model TV screens and computer monitors to generate visual output. CRT monitors are relatively large and bulky as well as containing a high amount of toxic chemicals such as lead.

Ecodesign. The integration of environmental aspects into product design with the aim of improving the environmental performance of the product over its full life cycle, including at end of life (e.g. designing computer equipment which is easily to upgrade or recycle).

EEE (electrical and electronic equipment). Refers to any equipment which uses electricity to function, whether this is powered by mains electricity, battery power, solar power or other means of power generation. This includes computers, televisions, MP3 players, refrigerators, mobile phones, radios, torches and so on. See also: WEEE

Extended Producer Responsibility (EPR). Refers to waste and product policy approaches that make producers take responsibility for their own goods over the full product life cycle, including (and especially) when they become waste. This means, for instance, producers fund end-of-life recycling and safe disposal of their products. See also: Take-back systems

Producer. According to the WEEE Directive, a producer is any individual or organisation that manufactures or imports and sells electronic equipment either under its own brand or equipment made by others rebranded as its own.

PRO (producer responsibility organisation). A cooperative industry effort to shoulder the responsibilities of its member companies and meet their EPR obligations. PROs may bear operational responsibility for ensuring proper e-waste management, by managing the financing, collection, transportation and control systems.

Reuse. This is defined by the WEEE Directive as 'any operation by which WEEE or components thereof are used for the same purpose for which they were conceived'. This refers to continued use of either individual components or entire pieces of equipment.

Recovery. This is the process of reclaiming the valuable materials from a particular piece of equipment which have been used in the construction process which then may be sold on and used for other purposes. In the case of e-waste this includes gold, copper or tungsten.

Recycling. This is defined by the WEEE directive as 'the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery'. It therefore involves processing waste equipment in order for it to be reclaimed. In comparison to reuse, recycling may alter equipment substantially during processing, and may not necessarily be used for its original function.

Treatment. This is, according to the WEEE Directive, 'any activity after the WEEE has been handed over to a facility for depollution, disassembly, shredding, recovery or preparation for disposal and any other operation carried out for the recovery and/or the disposal of the WEEE'. Treatment thus refers to the processes which equipment may undergo at its end-of-life and may include recovery, recycling, refurbishment or other forms of treatment. **See also: Recovery, Recycling, Reuse.**

WEEE. Waste electrical and electronic equipment refers to any electrical or electronic equipment, which is at its end of life. See also: EEE, WEEE Directive

WEEE Directive. EU legislation regarding the treatment of EEE that aims to prevent the generation of WEEE and to promote reuse, recycling and other forms of recovery in order to reduce the quantity of such waste to be eliminated.

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[96] For a more extensive overview of relevant legislation, see BEWMAN 2010. Legal Analysis

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[97] Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/data/wastestreams/weee

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