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E-waste Prevention, Take-back System Design and Policy Approaches

Duncan McCann, WEEE Help

Annelaure Wittmann, Enda Europe

solving the e-waste problem

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Editor: Ruediger Kuehr, United Nations University – Institute for the Advanced Study of Sustainability (UNU-IAS) – kuehr@unu.edu

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E-waste Prevention, Take-back System Design and Policy Approaches

by

Duncan McCann, WEEE Help

duncan.mccann@gmail.com

and

Annelaure Wittmann, Enda Europe

annelaure.wittmann@enda-europe.org

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Table of Content

List of Table

List of Figure

List of Case Study

List of Sidebar

Acronyms

ATF	Approved Treatment Facility
B2B	Business to Business
B2C	Business to Consumer
B&W	Black and White
BAT	Best Available Technologies
BFR	Brominated Flame Retardants
CRT	Cathode Ray Tube
CFC	Chlorofluorocarbon
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
EEE	Electrical and Electronic Equipment
EoL	End-of-Life
EPR	Extended Producer Responsibility
ESM	Environmentally-Sound Management
EU	European Union
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IPR	Individual Producer Responsibility
IT	Information Technology
LCD	Liquid Crystal Display
MT	Metric Tonnes
NGO	Non-Governmental Organization
ODS	Ozone Depleting Substance
OEM	Original Equipment Manufacturer
PC	Personal Computer
PCB	Printed Circuit Board
POM	Put on the Market
PRO	Producer Responsibility Organisation
PVC	Polyvinyl Chloride
PWB	Printed Wire Boards
REACH	Registration, Evaluation, Authorisation and Restriction of Chemical substances (EC regulation 1907/2006)
RoHS	Restriction of Hazardous Substances
SHEE	Second Hand Electrical Equipment
Step	Solving the e-waste problem Initiative
TV	Television
UNU	United Nations University
WEEE	Waste Electrical and Electronic Equipment

Abstract

This paper explores the large variety of policy options that have been implemented around the world and it draws some conclusions about the nature of responses to the e-waste problem and potential policy recommendations.

In the first decade of the 2000s, policymakers in industrialized and emerging countries focused their efforts on developing financing and awareness schemes aimed at ensuring better participation of both the private sector and individuals aimed at ensuring higher collection rates while maintaining the finances to meet the treatment costs.

The authors of this paper encourage further research on reducing overall e-waste volumes arising worldwide, encouraging repair and reuse both by producers and consumers and promoting eco-design, which are currently underrepresented in the literature.

In terms of policy recommendations, this paper seeks to present a variety of policy options, most of them having already been implemented to some degree in both industrialized and developing countries. A minority of recommendations are suggestions gathered from scientific work, the private sector or civil society organizations. The authors have tried to identify the advantages and disadvantages of each policy option, as there is no one-size-fits-all for e-waste policy and what works under some conditions may be inappropriate in others.

1 The e-waste challenge

E-waste has gained increasing attention over the last 10 years. This is in great part due to the fact that it is one of the few waste streams that is steadily growing and shows no sign of abating. Whereas many other waste streams are declining, e-waste continues to grow at an annual rate of about 5 per cent globally, as shown in the figures below. The problem is growing exponentially in the developing world, and the UNU-hosted Step initiative calculates that volumes could grow by as much 500 per cent over the next decade in some countries.[1]

Table 1 Evolution of Global E-Waste Volumes (Tonnes of E-waste)

Continent	Region	2009	2010	2011	2012	2013	2014	2015	2016	2017
Africa	Eastern Africa	0,1	0,1	0,2	0,2	0,2	0,2	0,2	0,3	0,3
Africa	Middle Africa	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2
Africa	Northern Africa	0,5	0,6	0,6	0,7	0,8	0,8	0,9	1,0	1,1
Africa	Southern Africa	0,3	0,3	0,3	0,3	0,4	0,4	0,4	0,4	0,4
Africa	Western Africa	0,2	0,2	0,3	0,3	0,3	0,3	0,4	0,4	0,4
Americas	Caribbean	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Americas	Central America	0,9	0,9	1,0	1,0	1,1	1,1	1,2	1,3	1,3
Americas	Northern America	6,8	7,0	7,3	7,5	7,6	7,8	7,9	8,1	8,3
Americas	South America	1,9	2,1	2,2	2,4	2,6	2,7	2,9	3,0	3,2
Asia	Central Asia	0,1	0,1	0,2	0,2	0,2	0,2	0,2	0,3	0,3
Asia	Eastern Asia	6,4	6,9	7,5	8,2	8,9	9,6	10,4	11,2	11,9
Asia	South-Eastern Asia	1,2	1,3	1,4	1,5	1,7	1,8	2,0	2,1	2,2
Asia	Southern Asia	1,7	1,9	2,1	2,3	2,5	2,7	3,0	3,2	3,4
Asia	Western Asia	1,2	1,3	1,3	1,4	1,5	1,6	1,7	1,8	1,9
Europe	Eastern Europe	2,0	2,2	2,3	2,4	2,5	2,7	2,8	2,9	3,0
Europe	Northern Europe	2,1	2,1	2,2	2,3	2,3	2,3	2,4	2,4	2,4
Europe	Southern Europe	2,3	2,4	2,5	2,6	2,6	2,6	2,7	2,7	2,7
Europe	Western Europe	3,8	3,9	4,0	4,1	4,1	4,2	4,2	4,3	4,4
Oceania	Australia and New Zealand	0,5	0,5	0,5	0,5	0,5	0,6	0,6	0,6	0,6
Oceania	Melanesia micronesia and polynesia	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
total		**32,3**	**34,2**	**36,1**	**38,1**	**40,1**	**42,0**	**44,1**	**46,1**	**48,2**

Unit: million metric tonnes = 1 000 000 000 kg

Source: Baldé, C.P., Wang, F., Kuehr, R., Huisman, J. (2015), The global e-waste monitor – 2014, United Nations University, IAS – SCYCLE, Bonn, Germany.

The increase in e-waste is the visible symptom of the "make, consume and dispose" culture that has permeated the developed world and is now spreading across the developing world. In addition, the e-waste flow is of significant interest to policymakers, because it has a unique combination of characteristics, including threats to the environment and human health through improperly discarded materials, potential opportunities to retain valuable resources by closing the loop of material flows and providing positive social outcomes by generating jobs and business opportunities related to proper disposal and treatment. There are also a number of key strategic materials contained in e-waste central to enabling the growth of green industries, such as solar cell manufacturing, electric car production, batteries and wind turbines. Implementing effective “take-back” systems for electronic and electrical equipment reaching the end of its useful life should be a priority for all actors interacting with this equipment in order to offset the threats and capture the benefits of managing this material.

The many facets of the e-waste problem stem from three key characteristics of this waste stream: (1) the aforementioned continued increase in overall volumes; (2) e-waste, despite substance bans around the world, continues to contain numerous materials that are considered toxic and have led to increased environmental concern about improper disposal and treatment of these products; and (3) the costs of recycling e-waste can exceed the revenues generated from the recovered materials. These high costs of proper recycling are due either to the complex management required to contain the hazardous materials or because of the difficulty of separating highly commingled materials in complex products, which leads to problems around financing responsible management. This can incentivise the illegal transboundary shipment of used Electrical and Electronic Equipment (EEE) to countries—under the guise of reuse—where they can be recycled at a lower cost, leading to increased profit for the brokers but without the safe management of the hazardous components. The combination of these facets can result in e-waste flows being handled without due diligence paid to the hazardous fractions that may escape into the environment, causing harm to human health and the natural environment or exported to countries where the economics of recycling can be profitable, mainly due to cheap labour or the improper treatment of hazardous fractions. In addition, complex combinations of materials coupled with substandard treatment and recycling methods can lead to a loss of key resources locked in the e-waste. As shown in Table 2, many elements vital to the production of EEE are in substantial decline in the Earth’s crust. Even though reserves should be seen more as a snapshot of known extractable reserves rather than a prediction of future availability, what is undeniable is that reserves are finite and that for some materials, we may see supply constrained at in the future.

Table 2 Critical Resource use in Electronics and Years of consumption remaining in global reserves

Metal	Use in electronics	World mine production	% Demand for production of EEE	Years of reserves left at today’s consumption	Years of Reserves left at half of US per capita consumption rate	% of consumption met by recycled materials
Silver	Contacts, switches, lead-free solder, conductors, etc.	20,000 tonnes per year	30%	29	9	16%
Gold	Bonding wire, contacts, etc.	2,500 tonnes per year	12%	45	36	43%
Tin	Lead-free solder	27,5000 tonnes per year	33%	40	17	26%
Copper	Cables, wires, connectors, PCBs, transformers	15,000,000 tonnes per year	30%	61	38	31%
Indium	Flat screen displays, semiconductors	480 tonnes per year	79%	13	4	0%

Source: StEP – from e-waste to resources (2011), New Scientist (2007), US Geological Survey Mineral Commodity Summaries (2007)

The forecasted scarcity coupled with increased demand from manufacturers and consumers has led to the price of commodities rising at an accelerated pace in recent years, as illustrated in Figure 1. Although 2011 was a high point in commodity prices, with 2012-13 showing a small decline, current prices remain higher than the overall trend of the 20th century would have predicted.

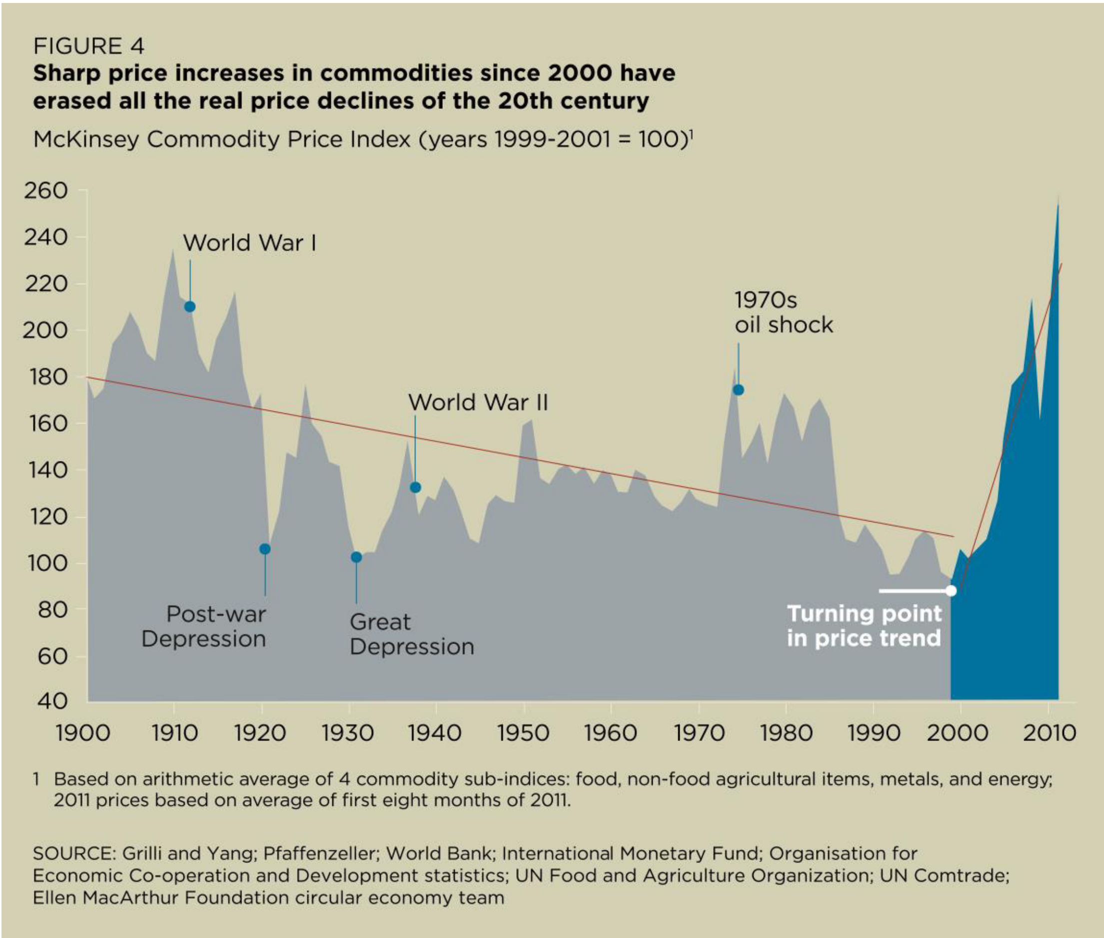

Figure 1 Sharp price increase since 2000 have erased all the real price decline of the 20th century
Source: Mckinsey Report, Towards a Circular Economy 2012

The threat of resource depletion represents one of the great incentives that may help ensure that e-waste is properly managed in the future. The recovery of the valuable materials in e-waste can alleviate some need for mining virgin materials. This not only mitigates the destruction caused by mining, but it also helps reduce the quantities of greenhouse gas emissions associated with extracting and refining virgin raw materials. For example, the urban mining of e-waste could provide 40 to 50 times greater concentrations of valuable materials, such as gold, silver and platinum, than from mined ore extraction. This means that more materials are available for the same amount of effort, while environmental pollution is reduced.[2] The increased price of commodities indicates a greater incentive to the recycling industry to invest in the appropriate combination of manual separation techniques and technological infrastructure to ensure that the greatest amount of valuable material is extracted from e-waste.

There are also positive social opportunities in creating good e-waste management systems. Many reports and studies indicate that increasing the total amount of collection can create job openings in collection services, the recycling industry and the repair and remanufacture sector, provided that additional volumes are not processed through increased automation.[3] These opportunities could be leveraged as manual device dismantling before processing at the recycling facility becomes the norm to extract ever-purer fractions and as reuse and remanufacturing become normalised parts of a product's lifecycle. As seen in Figure 2, each blue loop represents an opportunity to not only help protect the environment and human health but also to preserve resources and create meaningful jobs in areas such as equipment maintenance and device and component refurbishment and remanufacturing.

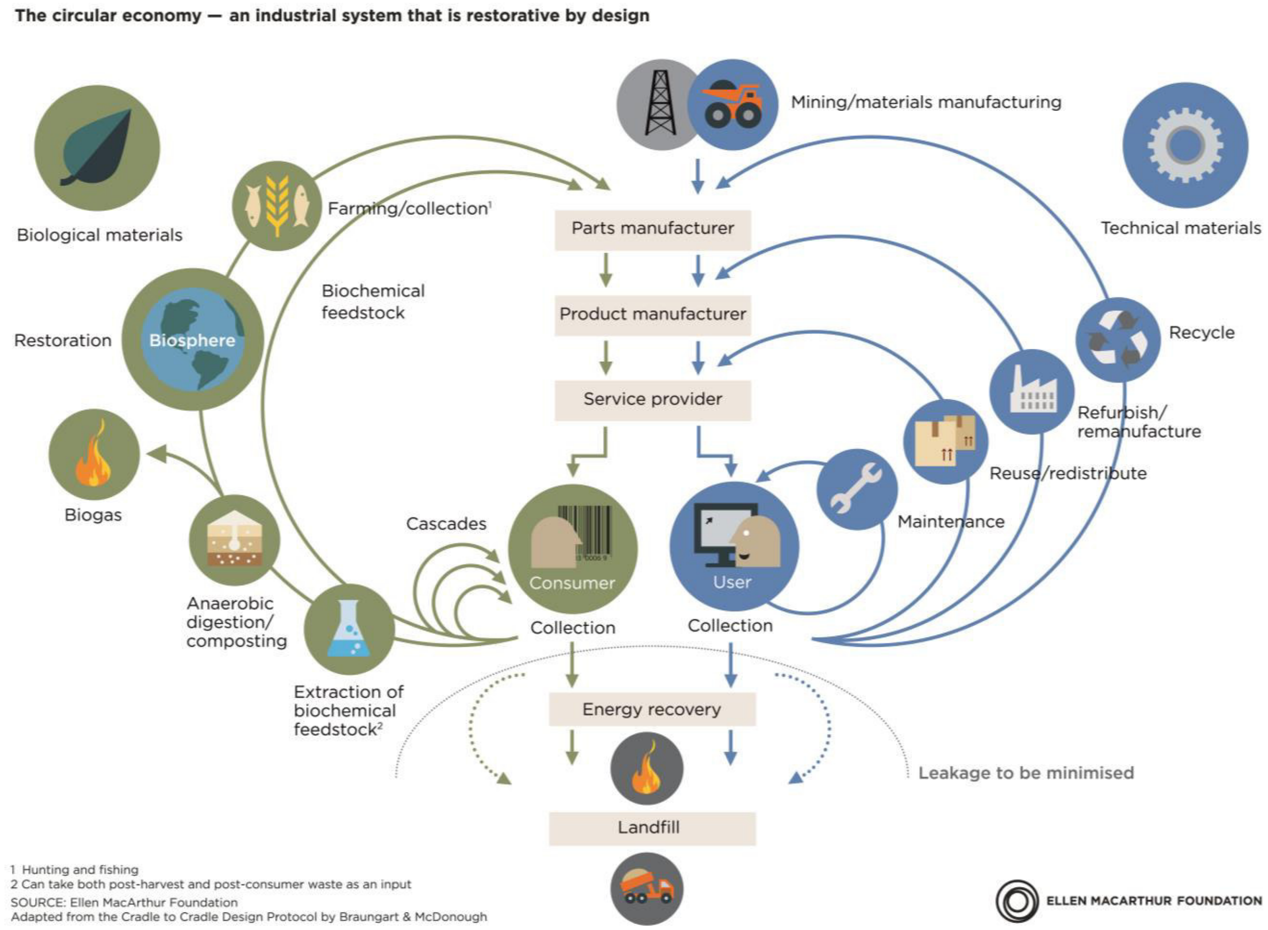

Figure 2 The Circular Economy – an industrial system that is restorative by design
Source – Ellen Macarthur Foundation

These concerns and opportunities have led policymakers around the world to create systems to collect and process e-waste either through direct regulation or by providing the necessary incentives. These systems are also known as "take-back systems". Japan, Taiwan, Thailand, India, China and South Korea have developed and implemented e-waste collection laws in Asia. Further, the Member States of the European Union (EU) have recently[4] completed the update of the Waste Electrical and Electronic Equipment (WEEE) Directive, which has assigned producers the responsibility for the financing and collection of End-of-Life (EoL) electronics. The European Member States are joined by other European countries with similar programs, such as Norway and Switzerland whose systems predate the EU system. North America has experienced a rapid increase in e-waste legislative activity over the past few years as well. As of September 2014, 25 U.S. states and eight Canadian provinces had already implemented systems or approved legislation creating electronics recycling systems. There remains, however, no appetite for federal legislation in either country at the moment. In Africa, Nigeria, Kenya and Cameroon have active legislation, and many countries are currently working on creating and finalising e-waste legislation in 2015. In South America, Argentina, Brazil, Columbia, Ecuador and Mexico have implemented legislation.

While it is commendable that policymakers have been trying to resolve e-waste issues around the world, they have been hindered until recently by a lack of knowledge and practical experience related to what systems would best create solutions for effective management and processing of EoL EEE in their respective region or country. It has become clear that exporting the language of the European Union WEEE Directive verbatim, which is widely seen as the benchmark for e-waste legislation, in unfeasible in many countries, especially those that lack public waste management system and a formal (e-)waste recycling infrastructure. Whereas collection has been the major issue in developed countries, with historic rates being very low, developing countries often excel at this part of the process. However, the collected material in these countries does not always get channelled into waste streams that result in responsible processing and recycling. It is therefore vital that for each element of any e-waste management solution, local characteristics and existing systems are understood so that the best policies and processes can be adopted.

There has long been a need for guiding information on EoL EEE take-back system design that would provide an overview and background information on design alternatives and highlight strengths and weaknesses in a variety of contexts. The primary objective of this Green Paper is to address this need by providing guidance to policymakers and system architects interested in creating or improving their take-back system in relation to the policy tools, design of collection systems, financing systems and potential alternatives to operate such systems.

A take-back system is a complex inter-related structure that has four key components: (1) the rules that govern the system, (2) the operational areas of collection and processing, (3) financing of the system and (4) how to control the flow of e-waste into and out of a jurisdiction. Each component will be addressed below with examples of how the area has been addressed by policy around the world as well as the relative benefits and issues of the relevant policy.

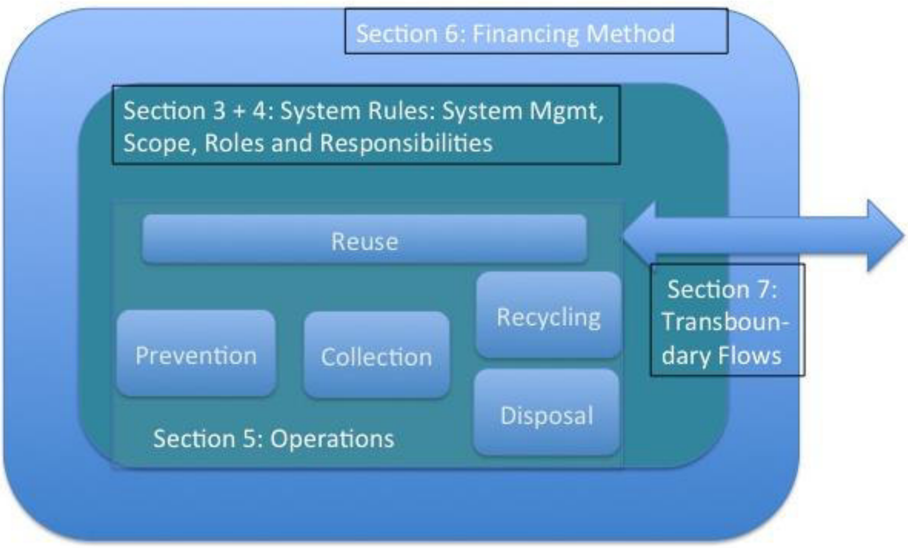

Figure 3 The Take-back System

2 How to read this document

This document is based on scientific evidence and lessons learned from the field. It presents 17 case studies from 15 different countries (five from Africa, four from Asia, one from Latin America, four from the EU and one from the United States).
This document begins in Section 1 with a description of the overall challenges related to e-waste management and the basic structure and components of a take-back system.

Sections 3 and 4 of this paper define and address the rules that govern take-back systems. These sections focus on clarifying who should be ultimately responsible for the success of the system and for the enforcement of its rules, what products should be targeted by the rule-setting and policies, and what the roles and responsibilities of the various stakeholders or actors should be. An examination of the principle of extended producer responsibility (EPR) is also presented, with particular emphasis on the context of this type of program in developing countries.
Section 5 covers the operational areas of a take-back system. The topic of e-waste prevention and its successful management in terms of collection, reuse, recycling and, as a last resort, disposal will be addressed in detail.

Section 6 covers how such a system can be financed to ensure that all of the management activities and operational functions can be carried out with a focus on efficiency (performance / cost) and effectiveness (total performance) and ensures its sustainability and eventual success.

Section 7 covers the topic of transboundary flows of used products and e-waste.
In addition, any policymaker or take-back system designer will need to consider what the primary goals are for creating their system. This will allow them to select the best policy choices to meet their most important goals. Some common goals for e-waste systems include:

- Motivate original equipment manufacturers (OEM) to improve product recyclability, reduce the use of toxic materials and integrate these concepts into product design[5]
- Prevent toxic materials from entering landfills or being incinerated
- Recover metals and plastics from e-waste, thereby avoiding the environmental burdens associated with producing virgin materials
- Ensure that e-waste is processed in an environmentally- and socially-responsible manner
- Share responsibility and financial obligations for ensuring the safe treatment of e-waste among stakeholders
- Motivate consumers to dispose of equipment correctly
- Create an efficient and sustainable system that will contribute to the local economy
- Improve the quality and health standards of recycling operations to reduce negative impacts on worker health
- Help bridge the digital divide through the extension of product life, by providing functional, low-cost repaired and refurbished equipment

A fundamental challenge in creating any system lies in balancing potentially conflicting goals to optimize it. It is also be important to manage and align the competing needs and interests of the various stakeholders, who may range from local and national governments to producers to consumers and civil society.
An area that will not be covered in this paper are the technical aspects of processing e-waste. This is already covered extensively in the literature[6], and policymakers typically focus on decisions related to aspects around generic processing standards (such

as export bans or environmental, health and safety guidelines)[7].

The individual elements of the system should be considered modular. Therefore, the best solution for any individual case will be a unique combination of the instruments provided.

3 What products should be included and prioritised

3.1 Determining what products should be in scope

3.1.1 Why this policy area is important

A critical topic for a proposed take-back system is to address is the scope of products that should be covered. Although every system should have as its long-term goal to cover all EEE, initial iterations can focus on a reduced scope to effectively and efficiently address the most urgent concerns and objectives.

Experience in this area is clearly divided into two distinct policy choices:

- The example of the European Union WEEE Directive, which covers all EEE products with a small list of exemptions.
- Other countries' policies have focused on a specified subset of products, based on:
  - the relatively large environmental impact of potentially improper treatment and disposal practices (e.g., for cooling equipment and the risks related to uncontrolled release of the cooling gases),
  - the volume of a particular product type in the waste stream, such as personal computers, laptops and televisions (CRT/LCD/LED), or
  - the infrastructure already present in the country

The decision made here will have many repercussions throughout the entire system, since it will govern not only the volume of material to be handled, but also the specific requirements for activities (not every product type needs the same treatment, is related to the same risk or generates the same costs or benefits) at all levels of the system. Accepting all types of products will mean that the basic system management activities that need to be carried out (such as producer registrations, consolidation reporting, monitoring and enforcement) will require greater resources and be more complex. It will mean that a greater variety of products need to be collected and processed, requiring more logistics providers and more storage warehouses. More equipment will then need processing, requiring an increase in the reuse, recycling and safe disposal infrastructure. When all of these things are not in place and when the prospect of setting them up is complex or cost prohibitive at the start, a full product scope will rarely be the best approach.

3.1.2 What are the policy options?

Full product scope

Until recently, the only two examples of policy options in which all EEE products were considered in scope were the EU WEEE Directive and the Swiss legislation. In late 2011, Nigeria passed their National Environmental (Electrical/Electronic Sector) Regulations and decided to proceed with a full scope, although it is yet to implemented. Nigeria's plan was followed by legislation in Kenya and Israel in early

2014 that echoes what had been done in the EU and Switzerland.

Both European systems were established within a country or group of countries that had a sophisticated local recycling infrastructure and culture that could be leveraged. Both instances also were in countries with high population densities that had means to set up and manage the network of collection points that could cope with the volumes associated with collecting all types of products. The data is not yet available to understand whether Nigeria will be successful in collecting all categories of equipment.
A country wishing to enact a full scope of products, even if they do not have some of the enabling characteristics listed above, may consider partnering with another country or region that has the infrastructure and environmental protection policies in place to appropriately handle and treat their collected e-waste while the country builds up its national infrastructure.

Phased product scope

Most system designers choose to focus on specific subsets of products. One reason for deciding on a phased approach could be if there is little or no e-waste recycling infrastructure. In such a case, it may be judicious to start with a reduced scope so that the volumes of products that pass through the system can be properly collected and treated. Then as the recycling infrastructure increases, the product scope can be expanded.
Alternatively, the take-back system may be designed with a focus on particularly problematic fractions from an environmental impact point of view. Many countries have chosen to focus on problematic product types such as cooling equipment in their first phase (e.g., China prioritised action on refrigerators and air conditioners to ensure that the harmful chemicals and gases are properly captured).
A third reason is that system designers may choose to focus on those products types that make up the largest part of the waste stream or have relatively short lifecycles. These types of systems can cover product types such as common household electronics like televisions, as well as high volume consumer ICT equipment like personal computers and their associated peripherals.

Table 3 Pros and Cons of various Product Scopes

	Pros	Cons
Full Scope	• Covers all products ○ Does not need further legislation when new product comes on market or if new environmental problem is identified	• Can add complexity to the system • Can strain recycling infrastructure until capacity is online • Can lead to a focus on recycling of non problematic but valuable fractions and products often more rewarding, cheaper and easier, unless specifically regulated against
Phased Scope	• Focuses take-back system on specific product types / groups • Can allow for iterative build up of scope and infrastructure in parallel • Can ensure that problematic products and fractions are dealt with as a priority	• Leaves large part of the e-waste without an official take-back system • Although many systems have talked about moving to full scope most have been reticent to enlarge the scope leading to long delays – British Columbia in Canada is the only current example of system that started with small scope and now covers all e-waste

3.2 Differentiating between business and consumer equipment

3.2.1 Why this is an important policy area?

In addition to product type, another key distinction that has been used by various take-back system designers to decide on which products are within the scope of the legislation is differentiating between business products and consumer products. There have been a number of different applications of the principle.

The underlying rationale for making this distinction is the same, even if the outcome and implementation differs widely around the world. The rationale that has been widely accepted is that business equipment does not flow through the same channels as consumer equipment when it becomes waste. When businesses discard equipment, this equipment does not enter the normal waste stream but it is either returned to the OEM or sold to another business user due to their residual value and the close relationship between the producer of the equipment and business user. They are then assumed to arrive at a recycler either through the OEM or through a company used by a business to handle the EoL of their products.

Although this certainly reflects actual practice in some cases, where the product is uniquely a business product, the reality may be quite different. A problematic area that has been identified concerns products that can be both a business and a consumer product, the so-called "dual use" products. These are mainly IT equipment, such as laptops, that are used regularly by businesses but are also available to consumers to buy. It is vital to ensure that all dual use products that end up in the consumer waste stream are properly financed by the responsible party. To avoid having un financed business products enter the consumer waste stream, most countries that have public e-waste collection points do not allow businesses to access these services for free. If a distinction is made between consumers and business, it is important to ensure that all dual use products are either classified as consumer products, with the associated obligations, or provisions are made by businesses to ensure proper treatment of all their equipment at EoL. An example of how to achieve this can be found in Section 3.2.3.

In addition, collection facilities that are free at point of use to consumers are usually financed through general taxes or upfront fees, paid by the consumer when the product is purchased as some countries mandate, so for businesses, these services normally need to be paid for at point of use.

3.2.2 Policy options

The EU WEEE Directive made the distinction between business and consumer products relevant in regard to what was needed to achieve compliance, as opposed to the system's product scope. This has meant that, in some countries like Belgium or France, products defined as business-to-business did not have to show a recycling fee on their invoices when purchased. This has also meant that it is possible to comply through the establishment of an company's individual takeback system rather than just via collective solutions that would mix business and consumer products.

An interesting outcome of the system in the EU is that from a single Directive, there a variety of mechanisms have emerged for determining whether a product is classified as business-to-business among the Member States. Some Member States, like the Czech Republic, decided to ignore the distinction altogether and consider all products consumer products for the pur-

pose of achieving compliance. The Netherlands adopted a policy in which the weight of the product determined its status. The weight chosen was 35kgs, meaning that any product under that weight was considered a consumer product. France took the most nuanced and interesting approach, as it sought to define business-to-business products by referencing some key product characteristics, such as technical specifications, size or intended use as well as the sales channel. Additionally, some U.S. states, such as Connecticut, Maryland and Minnesota, provide specific exemptions for products considered business-to-business in the scope of their legislation.
In summary, the choices available to take-back system designers, based on existing systems, are:

1. Exempt business-to-business products altogether, because the e-waste is normally captured and recycled already, as is the case in the U.S. states, mentioned above.
2. Use the business-consumer distinction to differentiate the financial and operational responsibilities that the producers of business-to-business products have from producers of consumer goods, as is done in most of the EU.
3. Remove any distinction between the two product types, and then open up all e-waste collection points to all users, be they business or consumer, an option which, at is the current policy in the Czech Republic.

3.2.3 Defining business products

A proposed best practice that looks at the product itself and the sales channel is included below.
Products can be classified as business product where:

1. Evidence in the form of a signed contract between the business user and the producer (or party representing the producer, such as a reseller under contract) that clearly assigns responsibilities for EoL collection and treatment costs, ensuring that the EEE will not be disposed of through municipal waste streams, or
2. EEE that, due to its features, is not used in private households and that will therefore not be disposed of through municipal waste streams. This should be supported by either one or a combination of the following criteria:
   a) EEE that is operated by specialised software or system environment requiring a special configuration for professional use
   b) EEE operating at a voltage or having a power consumption outside of the range available in private households
   c) EEE requiring professional licenses to operate, like Base Stations requiring the license of the telecommunication regulator
   d) EEE that requires a professional environment or professional education to be used as intended (e.g., medical X-ray equipment)
   e) Statistics showing evidence that a particular type of EEE is not disposed of through municipal waste streams (producer to provide justification and documentation)[8].

4 Who should do what within an E-waste Prevention and Take-Back System

4.1 Overall System Management – Who should control the take-back system?

4.1.1 Why this is an important policy area?

When establishing a new take-back system, it is vital to consider who will retain overall control and be ultimately responsible for the successful operation of the system. An entity must therefore be responsible for coordinating the specific actions of the various stakeholders who have roles and responsibilities within the system. In addition, an entity must also ensure that the system rules are enforced and compliance ensured. The manager of the system may be one of two different types of organizational entities that are outlined in this section.

The responsibilities of the take-back system manager may generally include some or all of the following: the collection of payments from the stakeholders; reimbursing collectors and processors of equipment once work has been carried out; setting and enforcing treatment standards; enforcing sales bans on producers who do not comply with take-back system laws; and approving processors and collectors to take part in the system.

4.1.2 Government

In some countries, states or provinces where take-back systems have been implemented, government agencies have been tasked with the establishing or managing the take-back system. In particular, government agencies that handle environmental affairs are typically given additional responsibilities associated with supervising system operations. However, some countries and states, like California, give primacy to the government agency responsible for business instead.

Government entities may be tasked with supervising a single take-back system for an entire region or multiple systems within a region. A government's role can be most effective by providing the necessary regulatory environment as well as ensuring that the rules are enforced.

4.1.3 Third party organizations

The management of the take-back system may also be carried out by a third party organization (TPO) that manages and administers the take-back system for its members. The TPO's membership may be made up entirely of manufacturers of the products being recycled but may also include government entities and other members, such as recyclers or collectors. Switzerland operates under such a management scheme, where SWICO, the local trade association for the IT sector, runs the take-back system on behalf of its members and coordinates with the national government to ensure compliance. There are similar systems for other types of products in Switzerland.

Activities carried out by TPOs vary from country to country, depending on specific legislation or decree that underpins them, and they can also engage in additional actives not specified by the regulations, such as audits.

Table 4 Pros and cons of options for overall Take-back system management

	Pro	Con

Government in charge	• Have powers of enforcement
	  ○ Levy fines
	  ○ Ban noncompliant producers
	• No potential conflict of interest
		• Not always most efficient economically, as this can lead to additional layers of administration
		• Can stifle (quick) innovation
		• Money flowing into and out of government departments can be problematic

TPO in charge	• More flexible – can adjust rules and outcomes more easily • Easier for TPO than government to develop relationship with members • Business incentive as costs and program can more easily be controlled and influenced	• Potential lack of enforcement mechanism • Can focus too much on their members and do not have the wider community and environment as interested stakeholders • Potential conflict of interest

In practice, however, some systems operate a shared responsibility model that can harness the best of both worlds.

Table 5 Roles of Government and TPO in practice

	New York	Switzerland	UK	Italy	Japan
Approval of collectors and processors	Government	TPO	Government	TPO	TPO
Collection of payments	Government	TPO	TPO	TPO	TPO
Reimbursing collectors and processors	Government	TPO	TPO	TPO	TPO
Enforcement	Government	TPO (but few tools available)	Government	Government	Government

4.2 Extended producer responsibility (EPR)

4.2.1 EPR Overview

EPR, as a principle, emerged in academic circles in the early 1990s. It is generally seen as a policy principle that requires manufacturers to accept responsibility for all stages in a product's lifecycle, including EoL management.

There are three primary objectives of the EPR principle:

- Manufacturers shall be incentivised to improve the environmental design of their products and the environmental performance of supplying those products.
- Products should achieve a high utilisation rate.
- Materials should be preserved through effective and environmentally-sound collection, treatment, reuse and recycling.

The key principle behind the reasoning that producers or manufacturers should be primarily responsible for this post-consumer phase is that most of the environmental impacts are predetermined when they design the product[9].

It is important to stress that EPR is not a policy in itself, but instead it is a principle that can be implemented through a variety of policy approaches. Some people have also narrowly defined EPR as to be almost a synonym with a mandatory take-back system or some sort of financial responsibility. By taking this narrow definition, they are missing the element of design for the environment and failing to appreciate the potential of the concept. The establishment of feedback loops from the downstream EoL management into the upstream design phase is at the core of the EPR principle, and is what can distinguish EPR policies from the implementation of a mere take-back system.

4.2.2 Collective versus individual responsibility

Under an EPR regime, responsibility can be assigned either individually, where producers are responsible for their own products, or collectively, where producers in the same product type or category fulfil the responsibility for EoL management together.

It is important to note that the benefits of design incentives are best achieved, all things being equal, through a system that is as close to Individual Producer Responsibility (IPR) as possible, because a producer will be most inclined to improve design when he is able to reap the benefits of the improvements. In a collective solution, if

Producer A improves the design of a product which leads to lower recycling cost or improved material recovery, then all producers in this product category will also reap the rewards of the improvement made by one producer. In the end, therefore, a collective solution would lead to progressive producers subsidising producers who failed to make any effort to improve their products.

IPR is, however, a more complicated system to administer, and examples of functioning IPR models are lacking. It is therefore advisable for countries developing new systems and policies to focus on collective EPR solutions before starting to individual organization solutions.

Case Study 1 Return Share Model of IPR - Maine, USA

Producer responsibility started in 2005 and the legislation specifies that 'each manufacturer is individually responsible' for all the collection and recycling cost in addition to a 'pro rata share of orphan waste', which can be considered waste arising from producers that have gone out of business or no longer trading.

Under the system, municipalities and collection sites collect e-waste and pass it onto a consolidator. At this point every product's brand is identified, counted and weighed.

Producers can opt for 3 different means of financing. they can collect a representative sample of e-waste from the collector, based on a return share, or pay the consolidator to recycle the e-waste, or have their branded products separated and recycle them themselves.

Orphan products currently account for about 2% of total product weight collected, responsibility for which is divided between all producers with more than 1% market share. It is no longer possible to offer for sale any product of a brand that is not in compliance with the legislation.

In 2010, the model was altered slightly so that only monitor and printer manufacturers are responsible individually, on a return-share basis. The financial responsibility of the manufactures of all other product types within the scope of the legislation are now calculated based on the relative market share of new product sales.

4.2.3 EPR and the developing world

Up until now, most examples of implementing EPR within a take-back system policy have been in the developed world, and while there are a number of challenges that need to be overcome, there is no evidence that EPR policies could not also be implemented in the developing world.

The major challenges facing implementation of EPR, and to some extent take-back systems generally, in the developing world are:

Lack of formal treatment facilities

A major hurdle for the producer to take up the responsibility results from the lack of treatment facilities (TF) compliant with international standards and related collection infrastructure channelling e-waste to these sites. This can be addressed by harnessing government support directed at ramping up compliant TFs or by market-orientated approaches that aim to leverage compliant recyclers to create their business case.

There are a variety of approaches to solve this issue. At one end of the spectrum there is the case of Taiwan, where the government created the necessary TF infrastructure under full public ownership. At the other end, market-driven models adopted by the likes of the EU and Japan, where the government set standards to be met by the TFs in order to obtain a license to operate. The latter example ensures that the market is regulated but also benefits from the fact that competition can generate environmental or economic performance improvements. Hybrid models between the government-controlled and the market-driven standard compliant operations have been tried in China and California, with the former offering cheap loans and the latter offering recycling subsidies for facilities meeting the compliance requirements. The real impact of these measures is, at present, hard to ascertain due to the very recent implementation of these policies.

Importantly, a lack of infrastructure should not prevent the implementation of EPR policies. Taiwan decided to store e-waste in the initial years of their program, since the established TFs did not have the capacity to process the e-waste collected. Another option, like that adopted in the small country of Luxembourg, favours the export of their e-waste to foreign facilities that can properly treat the arising e-waste. It is often better to develop infrastructure in parallel with the creation of the take-back system so as to avoid the creation of facilities in advance that are then under-utilized or redundant.

An established informal sector

Most countries, especially developing ones, have an active and vibrant informal sector that collects, repairs and resells used products as second-hand goods, and that recycles e-waste for its valuable resources. The term "informal sector" generally refers to the part of an economy that is not taxed or monitored by any form of legal authority, although the exact nature of the sector may vary from country to country. Without any interventions, the informal sector has an advantage over more formal collection and recycling systems due to lower treatment costs, as they do not have to comply with any standards, environmental regulations or pay local taxes, and this sector can potentially offer higher compensation to the collectors or legal owners of e-waste in return for handing it over to them. Because of the pervasive nature of the informal collection system in many countries, the formal sector could find it challenging to obtain access to a sufficient volume of e-waste to make larger treatment centres viable.

For some types of e-waste, environmentally sound treatment is a substantial cost, whereas for other e-waste types, the material recovery and reprocessing as new raw materials provides a positive net value. The informal sector is driven by the need to generate value from collected material in order that the sector may survive. As the informal sector is neither registered nor licensed, i.e. operating without control or standards, they can cherry pick (collecting and recycling the valuable fractions of waste only) and apply unsound treatment practices resulting in both risks to human health and the environment when recovering material and value.

The establishment of a formal sector needs to consider the existence and drivers behind informal sector operations in their local region and context, so as to integrate those participating into the overall solution. Support for a future recycling sector is vital and could take the form of regulations and standard setting as national requirements, in the form of capacity-building and trainings for the formal and informal workforce.

For the problematic e-waste fractions that do not offer the potential of any value from material recovery, the establishment of a means by which official treatment facilities can be compensated for having responsibly treated a specific volume of e-waste is required as an incentive for businesses to include the treatment of such fractions in their operations. This could be set up in a number of different ways, from the implementation of an upfront fee system to the back-end reimbursement by producer representative organizations once proof of the treatment has been provided.

E-waste that is illegally imported

Illegally imported e-waste represents a challenge for two major reasons:

- it provides a flow of material that helps to sustain the informal sector, which will continue to compete

with and hamper the development of a strong formal recycling sector; and
- this stream represents a drain on any e-waste system that is established in the same way as free riders and orphan products do by bringing additional volume into the system that has not been accounted for or financed.

This practice can only be stopped through efficient enforcement of existing rules at the federal level, especially the Basel Convention, along with proportionate and sensible polices, such as those outlined in Section 7.

Manufacturers not being based locally and products being imported by resellers

Since one of the primary goals of an EPR policy approach is to give manufacturers an incentive to improve the environmental performance of their products, any system that does not should not be considered an EPR system. This presents many countries with a problem, since many global companies do not import and sell their products directly. A very common model sees local distributors and retailers importing branded goods into a country for sale on the local market. It is these distributors and retailers, i.e. the importing party, that can be identified as the responsible party for e-waste management as they are legally registered and thus addressable in the respective country. Importers that do not manufacture their own products only have limited influence over product design, so it would seem to fall short of the primary EPR principles.

Potential threat to local reuse market

It is a common theory that a move towards an EPR policy approach can lead to a reduction or choking of the reuse market due to the competing demands with treatment facilities for the e-waste and used products. This is not a desirable outcome since reuse should, in general, be favoured over material recovery in order to prolong the lifetime of EEE. This theory seems to be confirmed in some existing EPR systems in the developed world that do not focus heavily on reuse and instead tend to focus on material recovery.

The reality in the developing world is that reuse organizations have easier access to desirable e-waste and used equipment by offering economic incentives "at the door" of the discarding consumers and by offering higher economic incentives, as they are not bound by operations controls and can cherry pick for value. For example, it has been shown that in Taiwan, a reuse organization is able to offer a price 44 times greater than the collection subsidy in Taiwan[10] for a laptop There should be no need to include these reuse organizations within an EPR system, since any cost for that product would have been incurred at either the initial point of sale or at the point of recycling, so the manufacturers will only be paying for the product to be recycled once.

Identification of the Producer in markets where "no-brand" equipment is common

A significant challenge that is often raised in the context of EPR in the developing world is the prevalence of equipment in the marketplace for which there is no real brand owner. Where the volume of such equipment is high, this can represent a serious impediment to implementing a successful EPR policy. This is because these products are either sold on the grey market, or because they are products assembled domestically from components of various brands, like PCs, are difficult to bring within the framework of an EPR policy as the manufacturer cannot be readily identified.

The lack of a clearly-identifiable producer means that any upfront fees system will not be able to identify a responsible producer and will therefore not contribute to the financing of any take-back system. Similarly, if funds are raised from identifiable producers, on a market share basis for instance, then they will be effectively forced to pay the costs of the no-brand equipment. Where producers seek to inter-

nalise the costs, as EPR approaches encourage them to do, this could then further skew the market as products from identifiable producers increase in price, making the no-brand equipment more attractive to the consumer and thus further increasing the proportion of this type of equipment requiring EoL treatment.
Although this problem seems complex, there are solutions to mitigate the complexity:

- Assembled products, mostly computers, can also be tackled by ensuring any company selling above a designated threshold be required to register as a producer and brand their products in order to be able to sell legally in the country. It is important that a threshold be set to ensure that very small businesses are not hit disproportionately hard by the EPR system.
- Ensuring the definition of a producer within the legislation captures the importer of product as well as the local manufacturer will create a level playing field if enforced.

The fact that EPR policy models may have been seen so far as unsuitable for implementation in the developing world[11] can thus be attributed to complicated problems that need to be resolved in the marketplace. Illegal imports, grey markets and polluting recycling systems are some of the symptomatic risks and threats that need to be corrected whether or not an EPR policy model is adopted.

4.2.4 Role of government in establishing a system

It is worth remembering that the EPR principles can be implemented under both voluntary and mandatory systems. The EPR principles indicate a market-based incentive and can draw lessons learned from existing voluntary practices in the business world. There are a variety of possible interventions that a government can make to implement EPR principles, and mandatory legislation is not always the best way to proceed.
Any system should seek to create a level playing field by promoting effective standards through the licensing and permitting of stakeholders. This helps to ensure that there is fair competition among producers, as well as between recyclers.
Although there are clear examples of successful business-led voluntary programmes, this represents the exception rather than the rule[12]. In addition, there remains a strong case for governments to influence businesses to operate in a more environmentally-sensitive and beneficial direction.

4.3 The role of the informal sector in industrialized and developing countries

4.3.1 Why this is an important policy area

The informal sector constitutes “work that takes place in unincorporated enterprises that are unregistered or small”[13]. First of all, it should be recalled that the concept of the informal sector should not be confused or identified with “illegal activities”.
According to the International Labour Organisation, the informal sector can be active in perfectly legal activities such as agriculture, urban transportation or waste management. The difference between the formal and informal sectors is that the informal sector does not pay taxes or contribute to a nation’s social protection system. It can, however, also include illegal activities such as trade with the mafia.
Informal workers have acquired their skills “on the job” or from family (not in the formal education system), they do not have access to social protection and they are organized mainly as self-employed (family companies or community-based groups).

In some locations, informal workers are not given licenses to operate within the legal system, and sometimes, even their existence is denied; they are often not taken into account in official statistics and public policies.

Historical background

In most Western countries, a public service of waste collection and disposal was set up at the end of the nineteenth century[14]. This public service was very efficient in achieving its mission of collecting waste as quickly and regularly as possible to ensure that infectious diseases had no time to develop. The waste ended up either in dumpsites or, a few decades later, in incinerators. This system marginalised the previously well-organized small waste pickers and recyclers and led to a reduction of the volumes of reused and recycled materials.

In the 1980s, many developed countries were alarmed by the increasing volumes and toxicity of waste collected, as well as the associated costs and spatial needs to manage the waste. They started to promote waste type separation at the source and the separate collection of recyclable materials. But by then, the informal sector had almost completely disappeared, and public authorities had to create collection systems and separation behaviour from scratch. This was the context in which the e-waste issue arose in industrialized countries. EU Member States, despite having the most sophisticated e-waste legislation in the world, still struggle to collect e-waste generated in their territory. For instance, the Netherlands, generally considered as one of the most environmental-friendly countries in the world, officially collected only 28% of the total volumes put on the market in 2010 via the two main organizations in charge of implementing the EU WEEE directive [15]. This figure rises significantly when channels omitted from the official statistics are included.

Socioeconomic aspects

In developing countries, a large informal sector still exists. According to the World Bank, 2 per cent of the global population works in informal waste management where they handle all types of waste. In China, it has been estimated that as of 2007, around 440,000 people were engaged in informal e-waste collection, and 250,000 people were engaged in informal e-waste recycling [16]. The informal sector provides income to people who would otherwise face even greater poverty. However, the impact on worker health and the surrounding environment of unsound practices in the informal sector (e.g., burning cables to recover copper) should also be considered, especially the potentially serious impacts on children[17].

The informal sector can sometimes have a positive impact on the economy as well. In Ghana, it is estimated that the informal collection, refurbishing and recycling of metal scrap, including e-waste, generates from 106 to 268 million USD nationally. It should be mentioned, though, that this sector does not contribute to the public budget directly due to the absence of taxes, and that the cost of de-pollution measures of informal e-waste management sites is not taken into account here.

Efficiency

According to field investigations, the informal sector collects and sorts larger amounts of waste than the formal sector in some countries[18,19]. In Ghana, 85 per cent of e-waste is collected by a well-organized informal sector that generates income for more than 30,000 people,[20]. The city of Cairo, Egypt depends on the informal collection and treatment as the only functional solution in waste management.

The informal sector is, to some extent, financially sustainable, as it draws most of its incomes not from grants or public money but from the market (i.e., the selling of recyclable materials to local or international recipients). For the workers, however, poverty rates remain very high. Most informal waste management operations that work without standards and externalize the environmental and human health costs achieve a short term net benefit, though formal waste management operations that operate under a strict regulatory environment have a net cost related to certain types of waste, including the problematic fraction that actually needs particular forms of treatment. This is due to the fact that the informal sector has been driven to focus on waste valorisation and therefore on "cherry picking", whereas the formal sector, when sub-contracted under the public service system, has a mandate to collect and treat all types of waste, including non-valuable products and fractions that require expensive treatment.

When considering all types of waste management, the informal sector saves public authorities large sums of money, mostly due to avoided collection and disposal costs (€ 14 million per year in Lima, Peru, € 12 million in Cairo, Egypt, and € 3.4 million in Quezon City, The Philippines, according to the GIZ[21]). Comparable numbers are not available for e-waste, specifically. UN-Habitat, in its last international report on solid waste management, even said that "the informal sector is clearly any city's key ally – if the city had to deal with these quantities of material as waste, then their costs would rise dramatically"[22].

Table 6 Strengths and weaknesses of the formal and informal sector

Steps in e-waste prevention and management	Formal sector	Informal sector
Reuse	✗ Does not intervene as much as the informal sector in this sector, although some sectors and companies are focussing on the issues	✓ Ability to identify re-usable products, refurbish them and resell them to "bottom of the pyramid" customers
Separation at the source	✗ Can be expensive if dependent upon public decision to impose mandatory separation at the source (especially for households) or upon negotiation with businesses. ✓ In some countries, can be labour-intensive when there is a low-cost workforce available.	✓ Ability to get access to e-waste even when there is no separation at the source, for instance in dumpsites or by providing incentives to waste generators (e.g., by buying it from households) ✓ Inexpensive and labour-intensive processing provides jobs for individuals
Collection	✗ Dedicated collection routes for e-waste can be expensive in the context of a formal waste management company ✓ Consumer behaviour in some countries, especially in Scandinavia, almost eliminate collection costs because consumers bring e-waste to recycling centres	✓ Thousands of itinerant workers collect scrap metals, including some e-waste types or buy it from households or waste pickers ✗Only economically-valuable fractions are collected
Dismantling	✗ Industrial dismantling (shredding) does not allow 100% recovery of the recyclable materials	✓ Manual dismantling allows recovery of a large portion of the economically viable recyclable materials contained in WEEE, even the very small parts (precious metals). It is also less energy consuming than industrial dismantling used in the formal sector.

Steps in e-waste prevention and management	Formal sector	Informal sector
Recycling	✓ Is able to make the substantial investments needed for safe industrial recycling	✗ No investment capacity and can only undertake manual or semi-industrial recycling (for instance, metal smelting or plastics recycling) that can be unsound and hazardous to health and environment practices in some treatment stages
Disposal	✓ Together with public authorities, is able to make the heavy investments needed for safe disposal	✗ Is not interested in final disposal

The positive benefits listed in Table 6 support why some authors recommend making the best use of the informal sector's strengths. These benefits also support the following concepts:

- Pre-processing (i.e., separation at the source, collection and dismantling of non-hazardous fractions of e-waste) should be the informal sector's responsibility.
- End-processing (i.e., the technical steps coming after dismantling (i.e., recycling and disposal)), some operations linked to pre-processing of hazardous components (CRTs, mercury, phosphor) and the recovery of complex but valuable fractions (such as the Printed Circuit Boards (PCB)) should be left to the formal sector[23].

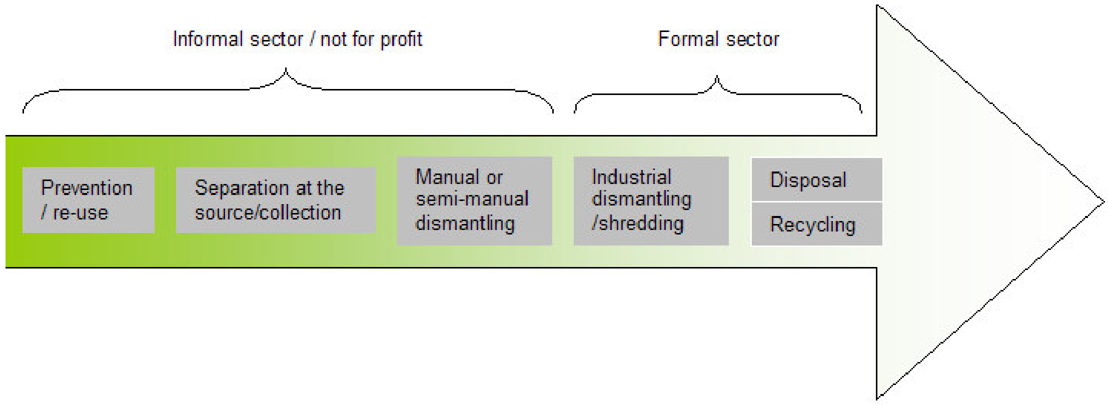

Figure 4 An illustration of one way responsibilities can be shared between the formal and informal sectors.

Figure 5 suggests that a number of countries would benefit from adopting the "Best of 2 Worlds" (Bo2W) approach by integrating their informal sector into formal e-waste management. The figure shows that it is countries with low labour costs, allowing for cheaper manual dismantling, and under-developed end processing infrastructure that could benefit most.

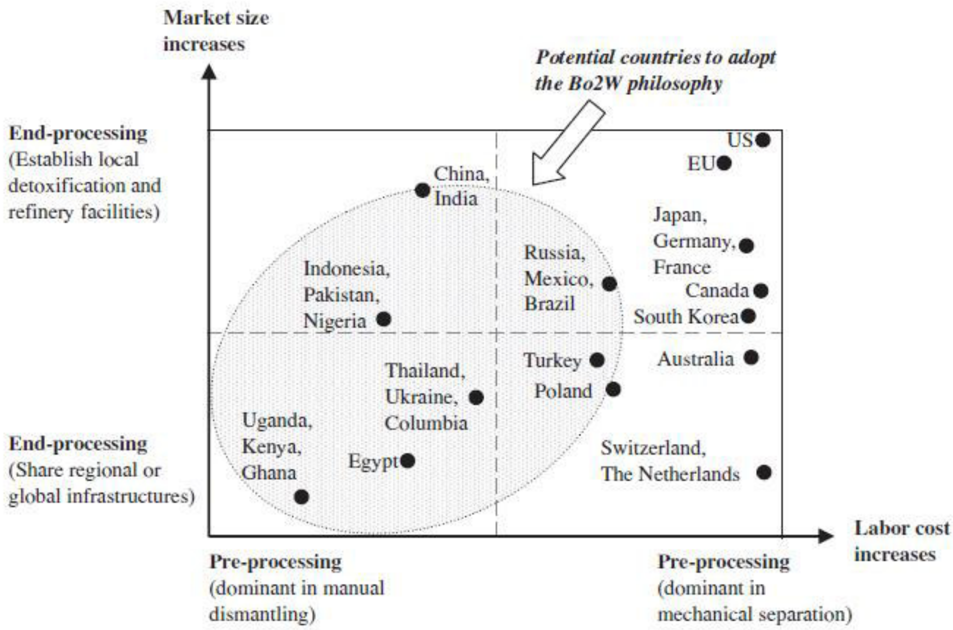

Figure 5 A suggested list of countries that could adopt the "Best of the two worlds" approach
Source: Wang et al., 2011, The Best-of-2-Worlds philosophy

See Section 5.3.6., "E-waste recycling, a local or a global business?", for a presentation of the Bo2W approach.

4.3.2 Policy options

Identify more precisely informal e-waste collectors and recyclers

There is a lack of information on the way the informal sector operates, and how this affects its workers, their business relations with the formal sector and its financial profile (prices, costs). This makes it difficult to identify an appropriate strategy to organize the sector and integrate it into the formal sector so as to improve workers' health and incomes and to better protect the environment.

Promote the inclusion of the informal sector (affirmative action)

In some countries, especially those in Latin America, well-organized informal recyclers managed to influence public policies, and they are recognized as actors who are integrated in the formal waste collection system. The Constitutional Court of Colombia has issued a decision against the City of Bogotá in December 2011 for not including enough specific measures to promote the participation of informal recyclers in the municipal tender on waste management[24]. One year later, the City of Bogotá decided to allocate a portion of the municipal budget to the payment of informal recyclers by the ton of recyclable materials collected[25].

Case Study 2 India and the informal sector in e-waste

Out of the growing amounts of e-waste generated in India (380,000 tons in 2007), only about 6 % is recycled, of which 95 % is recycled through the informal sector. However, the trend seems to be changing as more and more formal recyclers are entering into the e-waste sector[26].
The informal sector is particularly involved in collection, segregation and dismantling of WEEE, as well as re-use of EEE (through repair, refurbishment and re-selling on the large second hand market, in particular for IT products in India). Dismantling often includes the extraction of precious metals in unsafe conditions.

The "National Guidelines for the sound management of e-waste" issued in 2008[27] by the Indian Ministry of Environment, already encouraged the upgrading and formal recognition of the informal e-waste recyclers. But at that time, there was no specific national legislation on e-waste.
This is now the case since the "E-waste (Management and Handling) Rules 2011"[28] have been issued by the Ministry of Environment and Forests. It has come into effect across the country on May 1st, 2012[29]. It stipulates that "every producer of EEE, collection centre, dismantler or recycler of e-waste" (this implicitly includes the informal sector) must apply for licenses and comply with pollution standards and labour laws.
In 2008, there were only 2 formal e-waste dismantling facilities in India, in the cities of Chennai and in Bangalore[30]. In 2012, two new collection centres have obtained licenses in these regions, and a group of waste-pickers organised and were trained by Chintan, an environmental NGO, and Harit Recyclers Association (HRA), a collective of waste pickers[31].

However, integrating the informal sector is not enough, as the cost of waste management cannot rely on poor working conditions and low incomes experienced by the informal workers. It is therefore necessary to go one step further towards the professionalization of the informal sector.

Formalising the informal sector

A very small percentage of the informal sector is organized into associations, cooperatives and SMEs. Most of the informal workers are independent workers with a low level of education, and waste management is sometimes not even their main livelihood. This makes it complicated for public authorities to engage in a dialogue with these workers in order to raise awareness and standards to improve their health.
Identifying the informal actors in e-waste management that are already organized into associations or businesses and to work with them is one crucial step in finding a solution that integrates the informal sector.
The main objectives for engagement should be:

- Set up or reinforce organizational capacities, because as individuals informal workers are vulnerable, but when they are organized, a dialogue can be established with the local authorities, agreements can be signed, services can be delivered and followed through in a professional way.
- Improve participant working conditions and status (e.g., ecologically-sound waste processing techniques, occupational safety and health awareness). As a first step, informal e-waste collectors and recyclers should be made aware of the risks of inappropriate dismantling and recycling techniques. Then, certain practices should be progressively banned, such as open air burning of waste.
- Enable participants to train households on how to separate e-waste properly and identify hazardous waste, which will improve the efficiency of subsequent awareness-raising campaigns (see Case Study 3).
- Start a process and dialogue for registration and pre-formalisation of informal workers.

Once registered into legal structures, the informal sector should be supported to get access to:

- appropriate technologies to collect, transport, weigh, compact and pre-process recyclable materials;
- adequate warehouses close to their neighbourhoods to store recyclable materials safely and be able to sell them in bigger quantities to the local industry, thus negotiating fairer prices;
- community facilities to organize meetings and share experiences with other actors.

Case Study 3 Burkina Faso, Benin, Madagascar and the "Clic Vert" project, an example of financial incentives enabling to achieve good collection results

The Clic Vert project carried out by a local NGO Les Ateliers du Bocage Burkina and the international NGO network Emmaüs International with the support of Orange France was launched in March 2010 in Ouagadougou. Its objective was to collect and treat mobile phones in Burkina Faso.
An awareness-raising campaign targeting informal e-waste collectors and recyclers was carried out by Les ateliers du Bocage in 2011. At the same time, a TV programme was broadcast by the national TV channel of Burkina Faso to inform of the risks of inappropriate informal dismantling and recycling techniques, especially open air burning[32]. Collection was then organized by local staff that visited small retailers and collected used mobile phones and gave their owners new equipment in return (e.g., cables, accessories, battery chargers).
The Ateliers du Bocage trained more than 1,000 informal e-waste collectors and recyclers, collected 215,000 used mobile phones in the first 15 months of implementation of the project. As the project team saw no possibility to treat hazardous parts locally in an environmentally safe manner, they decided to send hazardous parts to Europe where they could be handled by European recyclers. The first container of 8 tons was in May 2011 from the harbour of Lomé[33].
In 2011, the Clic Vert project was extended to Benin and to Madagascar[34]and by mid-2013, 4 program units had already been opened in Burkina Faso, Bénin, Madagascar, and Niger. Each unit is supported by the Clic Vert project during 5 years, after that, the unit is expected to be sustainable. The funds mainly come from the mobiles collected in France that are refurbished or dismantled (material recovery).
Since it was launched, the Clic Vert project created 35 local jobs in collection and dismantling[35] with around 70 tons of WEEE shipped back to Europe for proper treatment.

Financing systems involving the informal sector

In most developing countries, the informal sector plays a key role in collecting e-waste, as it has the workforce and flexibility to carry out a door-to-door collection sometimes by directly buying used equipment to households and companies.

Yet, when countries set up a national legislation, they usually do not consider the informal sector in the financing system, as illustrated below by the case of China.

Case Study 4 China and the competition between the informal sector and the public subsidized "Old for New Program"

The Clic Vert project carried out by a local NGO Les Ateliers du Bocage Burkina and the international NGO network Emmaüs International with the support of Orange France was launched in March 2010 in Ouagadougou. Its objective was to collect and treat mobile phones in Burkina Faso.
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Case Study 5 China and the competition between the informal sector and the public subsidized "Old for New Program"

Driven by the need to boost official e-waste collection rates and to formalise the informal sector, the Chinese government implemented an innovative mechanism with strong financial incentive for consumers, collectors and recyclers. One condition of the legislation authorising this program was for collectors and recyclers to be formally registered by the government.
This public program was implemented from July 2009 through December 2011 in five large cities and four provinces. The procedure applied was as follows:

1. The consumer calls an official collector to get rid of his used equipment, for instance, a TV.
2. The collector picks up the old TV, pays the consumer a market price for the remaining value of the e-waste and gives the consumer a voucher.
3. With this voucher, the consumer goes to an officially-registered retailing store and buys a new TV with a 10 per cent discount. The government subsidizes the discount.
4. The collector sells the old TV to an official recycler. They agree upon a market price.
5. The collector receives a subsidy from the government according to the amount and type of e-waste collected and transported to official recyclers.
6. The recycler receives a subsidy from the government for the treatment costs, according to the type of e-waste accepted.

This system proved to be very effective in the short term: in only 20 months, 49.9 million used home appliances had been collected. There is, however, still a financial sustainability challenge for the official system. After the end of the subsidies in 2011, field visits have shown that the volumes officially collected have decreased significantly. This is an indication that consumers have turned back to informal collectors that are more competitive and flexible than official collectors, especially in the absence of public subsidies[40].

Allowing the informal sector to get access to public funds or funds raised by EPR mechanisms to cover their specific e-waste collection and separation activities can potentially be a powerful incentive to formalise the informal sector. For instance, public authorities can set as a condition to access these funds that the informal workers get organized, registered officially and commit to adhere to the legislation. If successful, such programs would clearly be win-win deals.

It is interesting to note that in early 2013, the City of Bogotá started to implement an action plan [41] to include informal waste collectors of recyclable materials including e-waste in its formal waste management system. Informal waste collectors are encouraged to register as "Authorized Recycling Organizations" (in Spanish "Organizaciones de Recicladores Autorizadas" – ORA), which involves complying with a set of criteria and controls defined by the city. They are then considered providers of the public service of waste management for which they receive remuneration based on a defined fee structure for handling the recyclable materials.

The experience of Bogotá has shown so far that it is a complex feat to implement such financing systems, as many practical issues arise. For instance, the concern of how to allocate specific "areas of waste collection" to formalized actors in neighbourhoods where many informal waste collectors still operate, but the move towards formalization and improvement of working conditions is launched.

Establishing fair partnerships between the informal sector and the recycling industry

The informal sector has been a supplier of recyclable materials for the industry for centuries. But this business relationship often lacks transparency and equity. A limited number of intermediaries collect recyclable materials from the numerous waste pickers and make large profits on reselling these materials to the industry, whereas thousands of small informal collectors and recyclers get very low incomes from their activity.

In India, a study revealed that 94 per cent of large enterprises and organizations do not have an IT disposal policy [42]. This means that when they renew their IT equipment, they sell the used equipment to those who pay the highest price and are best organized, without taking into considerations environmental and health issues[43]. In the EU, most companies renew their IT equipment every three or four years, and some do not send the EoL equipment for recycling or reuse, but use an outside waste contractor for disposal[44].

The industry can benefit from signing direct agreements with organized e-waste collectors, provided there is a good traceability of the collected e-waste.

Case Study 6 A not for profit-private sector partnership in France

The French association Emmaüs founded in 1949 is famous for its communities that collect and refurbish second hand clothes, furniture, books and EEE. In 1984, the association set up a social enterprise called Envie that started its activities in Strasbourg by opening the first second-hand shop selling repaired household appliances shop with a 2-year guarantee, in partnership with EEE retailers such as Darty. Envie also has a partnership agreement with Eco-systems, one of the 5 French compliance schemes for WEEE.

Envie Nord, the local branch in the North of France, specializes in the recycling of white and brown goods (refrigerators and TVs) and has set up a partnership with the recycling company Coolrec France. Coolrec France is then in charge of treating and recycling cooling agents in refrigerators and cathode ray tubes from televisions and monitors collected by Envie Nord[45].

Envie turned into a national federation of social enterprises in 2002, and since 2010 is a leader in re-use of EEE with 49 social enterprises, 42 second-hand shops, 29 workshops refurbishing 62,000 household appliances each year, 35 collection, treatment and recycling centres that collect 100,000 tons of EEE and treat 80,000 tons each year, and employing 1050 full-time equivalent persons in difficulty (with public subsidies), 450 staff and 400 volunteers[46].

Case Study 7 A not for profit-private sector partnership in Mexico

In the USA, Good Point Recycling owns major electronics recycling facilities in New England, managing TV and computer recycling programs throughout New England and New York. This company has set up a partnerships with a US-based non-profit organization called Comite Coordinador del Codex para America Latina y el Cariba (CCLAC) to establish a "sister company" in Mexico.
Retroworks de Mexico was created in 2006 by unemployed women, mainly above 50 years old, based in the town of Fronteras in the state of Sonora, in Mexico. They started to collect used TVs in Arizona (US) at the time when US consumers were disposing their analogue TVs in favour of new digital TVs. The members of the cooperative were trained in Good Point Recycling facilities on safe and professional repair and dismantling techniques. More than 6 women are now able to earn approximately 500 USD/month by selling repaired TVs in Mexico and exporting recyclable materials to the US-based or Asia-based industries[47].

Conclusion

In the context of developing countries, the inclusion of the informal sector in formal systems offers many advantages (e.g., flexibility, cost-effectiveness, social cohesion of—and incomes for—marginalized persons), but the inclusion requires additional measures on the part of the government to enter into a dialogue with, train and organize thousands of people who are often not spontaneously willing to cooperate.
The experience in India demonstrates how NGOs have played a key role in helping some of the previously informal e-waste collectors to get officially registered by the government, to comply with the new legislation, improve workers' health and safety and reduce negative impacts on the environment.
The case study on the Clic Vert projects shows that for African countries, where the consumption of mobile phones is growing quickly, used equipment can successfully collected in partnership with the informal sector. Well-trained collectors and repairers do already repair what is repairable.
The case studies show that financial or material incentives can be a key component in motivating consumers, small retailers, repair shops, e-waste collectors or pre-treatment facilities, especially in the context of developing countries. These incentives, however, are rarely viable in the long term, and such initiatives should be considered temporary. To be successful, such incentives should be accompanied by awareness-raising campaigns and dissemination of lessons learned to these numerous actors, as the challenge of improving the efficiency and effectiveness of separate collection and appropriate pre-processing remains.

5 The different steps of e-waste prevention and management

5.1 Prevention and reuse

5.1.1 Why this policy area is important, even in developing countries

The graphs in Figure 6[48] illustrate the consumption patterns of various regions of the world and clearly shows that the EU, the United States, China and Hong Kong consume more than half of the world's EEE.

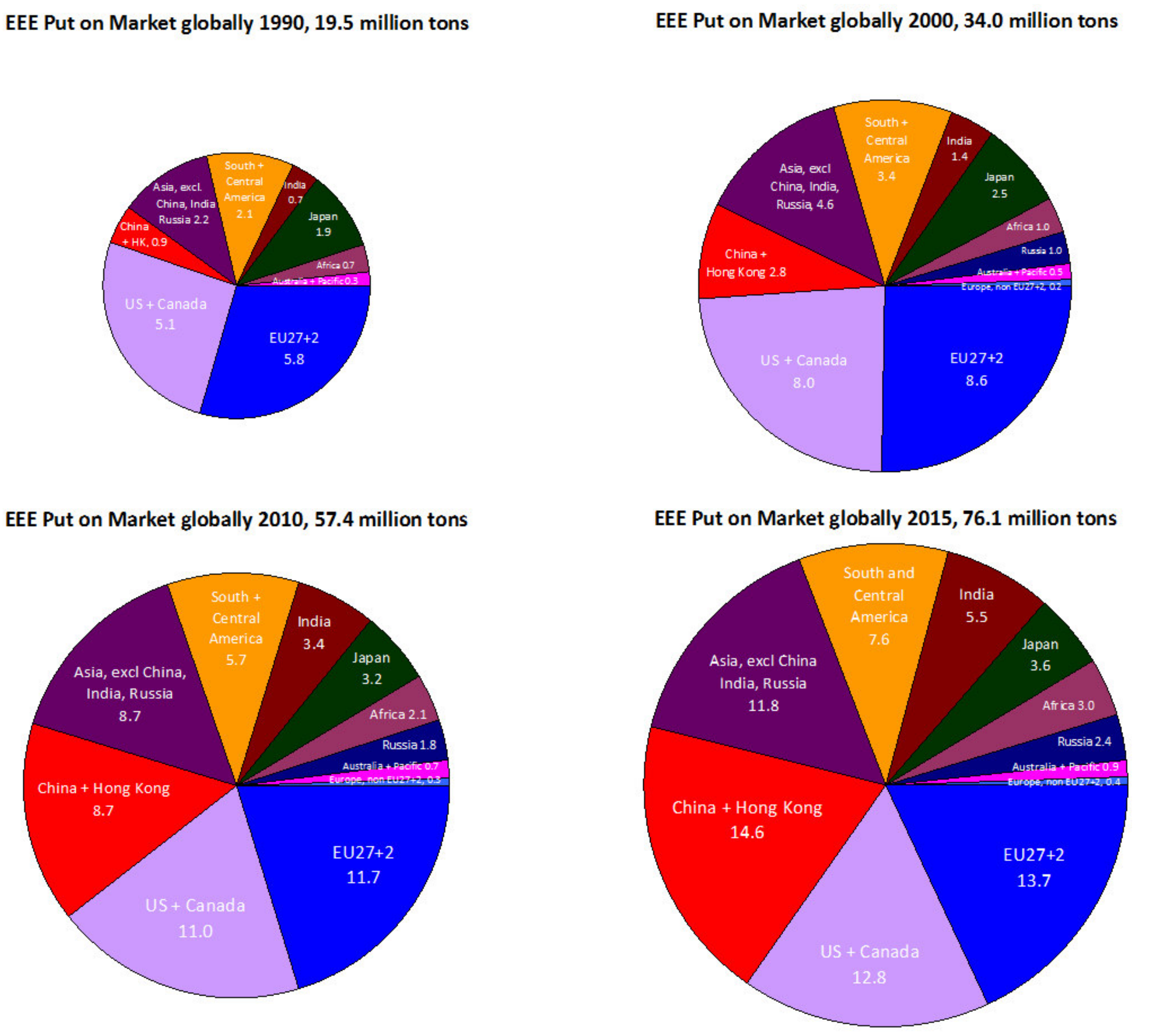

Figure 6 EEE put on the market, from 1990 to 2015, by region
Source: StEP Annual Report 2011

Even in Africa, which represents 1.5 per cent of the global consumption of personal computers, consumption of EEE is growing fast[49], and the public and private sectors are facing challenges to cope with the growing amounts of e-waste.

The "waste hierarchy" illustrated in Figure 7, where prevention is given primacy over other treatment options, is well-known, as demonstrated in the following example:

- The European Waste Framework Directive 2008/98/EC on waste management clearly states that "waste prevention should be the first priority of waste management[50]". This is done "with a view to breaking the link between growth and waste generation"[51].
- Japan has spent considerable effort promoting and implementing their "3Rs" approach. 3Rs stands for "Reduce" (volumes of waste generated), "Reuse" (reuse a good instead of discarding it) and "Recycle". In 2000, several laws on the 3Rs were enacted by the Japanese government, including the Fundamental Law for Establishing a Sound Material-Cycle Society. Japan has also spread the concept of "urban mining" (i.e., the need to recover the precious metals contained in even the smallest electronic gadgets [52]). The City of Kitakyushu [53] in Japan was a highly polluted place in the 1960s, and it has been implementing an Ecotown program including a target on zero

waste and appropriate recycling of e-waste.

- The State of South Australia, and in particular, the City of Adelaïde (with 1.1. million inhabitants), is famous for its Zero Waste programme. The state passed a Zero Waste Act in 2004[54] that established a company called Zero Waste SA. The goal was to reform waste management using the "waste hierarchy" as a reference, where the most preferable options are waste reduction and the last option is landfill.
- In Germany, the City of Freiburg is a leader of waste prevention, and the local government published in 2013 a handbook whose title perfectly illustrates the philosophy of the waste hierarchy: "Repairing rather than discarding, using rather than owning" (in German: "Reparieren statt wegwerfen, benutzen statt besitzen")[55].
- Around the world, millions of small repairers and second-hand shops have prioritized reuse and repair, as valuable goods are usually not discarded especially in poorer regions.

Figure 7 The waste hierarchy

Source: Zero Waste SA, South Australia

Sidebar 1 The benefits of extending a product's lifetime

Increasing product lifetime provides:

- **Environmental benefits**: It delays products becoming waste. Every time a consumer buys a second-hand product instead of buying a new one, it reduces the need to extract raw materials and consume energy in manufacturing, which reduces the impact of the environment.
- **Economic benefits**: Reduction in the number of products becoming waste represents significant savings for the taxpayers and the producers working under EPR principles.
- **Social benefits**: Second-hand shops and repair activities have traditionally been carried out by marginalised people, and in industrialised countries, by social enterprises or the not-for-profit sector. In the EU, it is estimated that reuse and recycling of e-waste carried out by social enterprises (enterprises that have social inclusion objectives prioritised over profit-making) can provide 10,000 jobs and collect/treat 200,000 tonnes of e-waste per year[56]. These jobs target "people at risk such as long-term unemployed, disabled and youngsters[57]". Second-hand or repaired goods are also very convenient for low-income households. Increasingly, there are other, for-profit operations that generate employment and economic revenues in this area.

There are surprisingly very few studies or public policies that tackle the issue of e-waste from a prevention perspective. Even the StEP Initiative, the largest international multi-actor network specialising in e-waste issues prevention has paid little attention to e-waste minimisation strategies.

Prevention and reuse are better than recycling

Most industrial groups and public policies are currently primarily focused on recycling and safe disposal of WEEE rather than on reuse of EEE. For instance, the original European WEEE directive set a target of 45 per cent for recycling to be achieved by 2020, but no specific target for reuse. And yet, prevention and reuse are on top of the waste hierarchy, because they are "environmentally preferable to recycling due to energy savings in the production phase and raw material usage, except where inefficient products remain in service"[58].

From a technical and economical perspective, e-waste is a great challenge for the recycling industry, because each product is made of dozens of different materials that are mixed, bolted, screwed, snapped, glued or soldered together. As potentially toxic materials are attached to non-toxic materials, the industry requires specific measures to protect workers' health and the environment[59]. In the industrialised world, reuse does happen but often informally through eBay, classified ads, flea markets and other secondary market routes; formal initiatives are not very widespread.

In other words, the best e-waste is the one that does not exist. Extending the lifetime of EEE does not prevent e-waste from occurring, but it delays the process and keeps the resources already used to manufacture products in use, which is already a step towards solving the e-waste problem.

Efforts to minimise e-waste

In industrialized countries, consumers tend to renew their appliances more frequently, especially ICT appliances such as mobile phones, laptops and computers. For example, mobile phones renewed every 18 months on average in industrialized countries[60]. Informal reuse and secondary market outlets have evolved, such as eBay and traditional refurbishes, to prolong the lifetime of equipment, in particular by giving the used equipment a second, sometimes a third or a fourth life. However, these new routes are not enough to offset the quick renewal by consumers of these products.

This decreasing longevity of products is driven by production and consumption patterns where consumers are fascinated by the modernity of EEE, low prices for new technology and new models and innovations that are frequently launched on the market[61].

Decreased longevity can result from:

- technical obsolescence (the product does not work anymore, from a technical perspective);
- economic obsolescence (new, cheaper products are launched on the market, or it is not economically viable to repair);
- feature obsolescence (new products have come onto the market with more or better features, such as smartphones replacing mobile phones); and/or
- aesthetic obsolescence (new, more fashionable products from the point of view of the consumer)[62].

But this "obsolescence" phenomenon is not always negative. In some cases, the renewal of an appliance has a positive impact:

- on the environment, for instance, if the new appliance is more energy-efficient or uses less resources (e.g., washing machines), is free of ozone-depleting substances (e.g., refrigerators), or reduces GHG emissions[63]; and/or
- on human development, as the proliferation of EEE that can help "bridge the digital divide" by allowing access to information for millions of people, or by acquiring more effective medical equipment.

At the end of the day, despite the considerable reduction of the size of equipment over the last decade, increasing reuse in developing countries and the phasing-out of some hazardous substances driven by ROHS regulation around new products traded globally, e-waste volumes continue rise due to the increasing consumption.

In parallel to these new consumptions patterns, production of EEE has become increasingly centralised, notably in Asian countries, which has contributed to lowering the production costs and therefore product prices. For example, the price of a computer has dropped to one tenth of its price 15 years ago[64].

While production efficiencies have been improved due to centralisation, most of the materials contained in EEE do not come from renewable sources. Metals and plastics are refined derivatives of ore and oil, both of which are found in limited quantities underground and must be extracted by the so-called extractive industries. Extracting and refining processes are recognized as high-impact activities due to excavation of the natural resources, contamination of water and soil in fragile ecosystems and generation of toxic wastes[65].

5.1.2 Policy options

One ton of disposed paper does not have the same impact on the environment as one ton of disposed mercury. This is why waste prevention aims at minimising both the quantity of waste and its toxicity. Waste prevention policies refer to "measures taken before a substance, material or product has become waste, that reduce:
(a) the quantity of waste, including through the reuse of products or the extension of the life span of products;
(b) the adverse impacts of the generated waste on the environment and human health; or
(c) the content of harmful substances in materials and products[66]."
Therefore, policy should tackle both the quantity of e-waste generated (quantitative prevention) as well as its toxicity (qualitative prevention), which can prove more complicated to manage or regulate.

Potential waste prevention measures can be divided into three broad groupings:

- framework measures that have a long-term impact on the economy, innovation or consumer trends;
- measures affecting the design, production and distribution phase (i.e., the responsibilities of manufacturers and distributors);
- measures affecting the consumption and use phase (i.e., the responsibilities of consumers).

Eco-design to manufacture less toxic and less wasteful products

Public authorities can choose to:

- ban the use of toxic substances in EEE, as in the European ROHS Directive, which forbids four heavy metals (lead, mercury, cadmium and hexavalent chromium) and the flame-retardants PBB and PBDE in new EEE. It can be desirable for a jurisdiction wishing to implement substance bans to create direct copies of this EU Directive, as has been the case in China and California for example. It should be noted here that continuous research is needed to assess the toxicity of new substances included in post-ROHS products as a replacement of the substances banned by ROHS[67].
- encourage or oblige manufacturers to provide clear information to the consumer on the characteristics and environmental performance of a product, or on how to minimise the environmental impact when using a product, as specified in the European Ecodesign Directive of 2009[68].
- promote research and development to enable the private sector to design and produce less toxic, more recyclable and less wasteful products and technologies.

There has been a lot of research and efforts by the EEE industry over the past few decades to reduce the energy consumption of EEE driven by initiatives such as the ENERGY STAR standard created by the U.S. Environmental Protection Agency that ensures that qualified products use less energy than standard products[69]. This initiative has now been adopted by a variety of countries because of its effectiveness.

The energy efficiency of appliances such as televisions, refrigerators and washing machines has improved in the last decades. When consumers dispose of their old appliance to buy a new, more energy-efficient model, there may be positive impacts in terms of energy savings. This trend has also contributed to an increase the amount of EEE generated. On the other hand, the global use of energy is still increasing as more EEE is consumed by individuals in the developed world and access to EEE in developing countries increases, offsetting the gains made by more efficient product design. Therefore, the challenge is to design and produce goods that are energy-efficient, long lasting, less toxic, reusable and recyclable.

Rather than creating new labels, existing eco-labels could include lifespan, reusability and reparability considerations (such as the ENERGY STAR labels) as a means to help consumers select the most eco-friendly product. Communicating these considerations through new or existing labels has proven to be quite complicated for multiple reasons, including determining the criteria, control mechanisms to ensure product compliance and how to present the information most effectively to consumers. Further effort is needed to overcome these challenges, because consumers should be better informed about such product attributes.

The integration of environmental and waste prevention criteria in public and corporate procurement could help expand the market for good quality, second-hand EEE. These criteria could cover not only energy efficiency issues, as is currently the case in some existing "Green Public Procurement" schemes[70], but also include eco-design, recyclability and lifespan of EEE.

Responsible consumption to increase the longevity of EEE

According to a 2003 study, the production phase for a laptop PC consumes almost the same quantity of resources as the use phase. In addition, almost 80 per cent of the energy is consumed in the production phase[71]. The components of a PC, such as PCBs, LCDs, and integrated logic and memory chips, require intensive upstream processing both in their manufacturing and in gathering the materials that make them work, such as precious metals. Miniaturised products, such as smartphones, also consume significant resources during production as compared to their use phase[72]. Extension of the use phase of EEE is a key policy option from an environmental point of view, because it allows these resources to continue to be used rather than disposed of and replaced by new virgin materials.

From the economic point of view, the cost of repair can sometimes outweigh the cost of a new product due to factors like labour costs or unavailability of spare parts. This is particularly true in industrialised countries where the repair sector is facing a lack of demand[73]. In France, 40 to 50 per cent of large household appliances are replaced when they are technically still functional or could be repaired. The breakdown of a product constitutes an incentive to buy a new product[74].

In case of a breakdown, a consumer is more willing to have a product repaired instead of buying a new one if the product is warranted by the manufacturer. In the European Union, the minimum legal warranty that has to be granted by manufacturers is two years. The product may however have a longer lifetime potential than this, if properly maintained, along with a majority of consumers expecting longer lasting products[75]. This disconnect between warranty length and product lifetime is one of the reasons why the French and Belgian parliamentarians have discussed the potential of creating laws to encourage the extension of the legal warranty period to up to 10 years[76]. This would enable consumers to get their products repaired for free by the manufacturer or the distributor, and thus postpone the moment when the consumer disposes of their product.

It is also important to implement specific awareness-raising campaigns to change consumption patterns from "own, use and discard" to "use, reuse, repair and recycle". Campaigns targeting consumers should promote careful consideration in consumption (avoid buying wasteful gadgets), reuse and/or repair practices. A successful awareness-raising campaign is generally led by a powerful, simple message that does not stigmatize customers or make them feel guilty. It should present a positive gesture that everyone can do. For instance, the City of Vienna, Austria, encourages its residents to sell or donate their products, notably EEE, rather than discard them under the well know motto "Old, but good" (in German: "Alt, aber gut"[77]), which stresses that second-hand products in good condition can still be useful to someone else.

Second-hand goods tend to be invisible in the economy, as they are collected and sold through informal markets in developing countries or in community-based markets (e.g., flea markets, charity events, donations within the family or neighbourhood) that are not captured by statistics on these products. In the UK for instance, more than 300 community-based organizations sell or donate second-hand goods to people in need, not only old clothes and furniture, but also EEE[78].

Distributors can also offer refurbished or second-hand products in their shops. Next to the new products, they can have a special area where they sell good quality repackaged second-hand EEE. Some mobile phone operators and ICT vendors have already set up such "second-hand corners" in their shops, such as Sprint in America. The advantage for customers is that they can have access to the same brand products but at a much cheaper price and sometimes even with a warranty period.

According to a survey carried out in the repair sector in Nigeria, EEE taken to repair shops can be used two to five years longer, on average, depending on the product. For instance, a mobile phone after repair lasts between six months and two years. Some household equipment can even last up to five years after repair[79].

Public authorities can facilitate the access to repairing services by:

- promoting the visibility of the sector (e.g., handbooks with the contact details of repairers in a given city or territory, webpages with similar information) and
- reducing the taxes on the repairing services.

More services, less e-waste

The idea behind dematerialisation is that the society should find solutions to continue to cover human needs (e.g., access to water, food, health, education, communication, transportation, leisure, etc.) using less materials and by generating less waste than currently occurs.

Some efforts have been made in terms of product miniaturisation and to develop a "dematerialised information society". Computers or mobile devices able to store huge quantities of information through high-density components such as flash drives or by accessing "the cloud". These developments give the impression that our impact on the environment is minimal, because the products are smaller but more powerful. However, the increasing amounts of e-waste generated worldwide show that neither miniaturisation nor virtual networks have dematerialised our economies and lifestyles[80].

Businesses and public authorities should encourage citizens to break the vicious circle of buy-use-waste, where the consumer is the owner of the product and to change consumption patterns towards services where a product can have several owners during its lifetime, managed by the manufacturer or their distributor.

This means :

- promoting hiring of services rather than product purchase, where a consumer "hires" equipment for a one-time use (e.g., mobile leasing schemes by operators that can sell services detached from selling devices);
- sharing of goods, where there could be a common washing machine in an apartment complex that can save space in the apartments, remove the need for natural resources to produce multiple appliances and reduce the volumes of e-waste; and
- encouraging second-hand markets and specialised shops where consumers can sell their used EEE to other consumers who want to access the equipment at a lower price than retail.

Conclusion

Reusing a product and extending its lifetime is the most effective, environment-friendly option as compared to discarding it. A simple indicator that can be used to monitor the impacts of an e-waste prevention policy is the quantity of used EEE disposed of per year. There are no indicators available so far to assess qualitative e-waste prevention through efforts to reduce the use of toxic components in EEE, because of the challenge of tracking toxic components in highly sophisticated appliances.

5.2 Separation at source and collection of e-waste

5.2.1 Why this is an important policy area

Separate collection and safe transportation are vital elements to the design of a well functioning e-waste management system. Effective collection and transportation will be one of the key elements to ensure that the valuable materials in the equipment can be extracted and recovered, as well as aiding containment and neutralization of hazardous parts and components of the products.

There are three key areas that should be considered by e-waste system designers:

- how to ensure that the largest possible proportion of the e-waste that is available to collect is safely collected;
- that e-waste is not combined with domestic waste or other industrial waste; and
- how to deliver the e-waste to the reuse facilities and recycling facilities with minimal damage or material loss.

It is also very important to recognise that this is an area where there are stark differences in the needs of countries to address this complex problem. This is an area where the developed world can indeed learn a lot from the experience of the developing world.

In the developed world, collection of e-waste is one of the most difficult issues to resolve. For some product categories in the EU, collection rates are still relatively low while others are quite high. For example in the Netherlands, more than 75 per cent of large household appliances are collected, whereas less than 45 per cent of the available small household appliances are collected.[81] Most countries in the EU have set up a wide range of collection points and infrastructure, but they still struggle to collect more than 30 per cent compared to the previous three years' volumes of products placed on the market[82]. One of the key drivers of policymakers and stakeholders of the WEEE Recast was to find ways to improve the official collection rate. This is an interesting illustration of how successful e-waste management systems are a function of consumer behaviour and attitudes towards waste as well as well-designed system elements.

The countries that currently have some of the best separate collection rates in the world are those where little or no policy has been implemented, and the system has grown up organically. Case study 7 provides an illustration of this point from Ghana.

Case Study 8 Separate collection of e-waste in Ghana[83]

Even though Ghana has no legislation currently implemented, collection rates are already very high, by some estimates over 95 per cent of equipment at EoL, and with almost no e-waste ending up mixed with other domestic waste. In order to achieve this rate, three different tiers of collectors have emerged. On the front line are the informal collectors that form the main backbone of the country's collection infrastructure. Some are mobile and go door-to-door to pick up e-waste, sometimes paying the discarder to for the e-waste. Others operate by sifting through bin, landfills and other informal waste dumping grounds to find e-waste.
The next tier is made up of the formal e-waste collection companies, of which there are a few in operation. They perform a similar door-to-door collection services as informal collectors, but because they have to meet the cost of treating the hazardous fractions of the e-waste, they find it hard to compete against the informal sector.
Finally, there is the domestic waste collection service where about 5 per cent of the WEEE ends up. This material is taken to a landfill, where an estimated 95 per cent is then re-collected and separated by the informal sector.

It is also important to organize the separate collection of e-waste according to the properties of the equipment. For instance, it is very important to separate the hazardous items, such as freezing and cooling equipment, from general e-waste to ensure that the hazardous fractions do not escape. Determining what equipment is collected and handled according to its hazards will be a factor in determining which products are in scope for the program and how the collection infrastructure is developed.

5.2.2 Establishment of a collection infrastructure

In order to achieve stated collection targets, a collection infrastructure needs to be established, as does a formalisation of any existing collection systems to ensure it is done in accordance with the principles of the take-back system. In this context, "formalisation" can range from recording the activity of different collectors to requiring registration to setting standards for the collection service.
The principal means of enabling a collection network are through a combination of the creation and formalisation of permanent drop-off facilities, special drop-off events and door-to-door activities. The methods by which the collection will be achieved and the responsibilities are assigned to the various actors involved in this work will all depend on the type of actor that is being considered. The table below summarises the typical collection mechanism for four key stakeholders, followed by a more detailed examination of the various methods.

Table 7 Key stakeholders and Collection methods

	Informal	Government	Retail	Commercial	OEM
Permanent drop-off location	Located in specific markets or informal business locations	Co-located with offices or other waste drop off locations	Located at retail stores	Located at company facilities	Location created in partnership with one of the other three stakeholders
Special drop-off event	N/A	A one or two day event dedicated to generators dropping off e-waste at a location affiliated with the stakeholder			
Door-to-door pickup	Collection from general public directly	Resident door to door collection	Collection upon delivery of new appliances	Direct pick-up, especially from other commercial entities	Pick up by mail or logistics company

Permanent drop-off facility

These facilities offer a location for people discarding e-waste, or generators, to drop-off e-waste all year round. Permanent drop-off facilities are often associated with government entities, such as municipalities. These facilities are typically co-located with drop-off sites for other types of waste.
A retailer could locate a drop-off facility within its store, and a commercial entity, such as a recycler, could accept e-waste from generators at its facility. An OEM can often partner with one of the other entities mentioned above to create a permanent drop-off point.
Any permanent drop-off facility must be capable of storing some e-waste, because recyclers will rarely collect the e-waste on a daily basis. Rather, transportation to the recycler will occur when the waste can fill a truck or when the hauler can include a pick up in its schedule.
A linked policy instrument whereby retailers are required to either accept e-waste on a one-to-one basis when new products are bought or as true permanent drop-off facilities under a zero-to-one system will be discussed below.

Special drop-off events

These are generally one- or two-day events dedicated to generators dropping off e-waste at a location affiliated with the organization collecting and handling the dropped off equipment. They can be held at a temporary location (e.g., a parking lot) or a permanent facility. Publicity is a key component of maximising the effectiveness of a special event, and the event serves the dual purpose of increasing collection rates and educating the public on e-waste recycling options and best practices.

Door-to-door pick up

This is the most costly of the collection options in the developed world, but also has the potential to collect equipment that is in better condition, since it has not had to endure potentially unsafe transportation to a facility or disposal in large bins generally present at permanent sites and special events. The informal sector in developing countries can collect door-to-door for a much lower cost.
Some municipalities have started to offer door-to-door collections for large domestic appliances on a rationed basis, meaning that each resident may call on the service a few times per year for free. Service limitations generally vary locally. In London, England, most residential homes can have large domestic appliances collected four times per year at no cost to the household [84]. Other entities have focused on providing the service for a fee to cover the cost of collection and recycling.
Commercial entities often use direct pick up as a collection mechanism, particularly when collecting e-waste from other commercial clients who generate significant volumes of e-waste. However, economic incentives may create situations where some commercial entities engage in door-to-door pickup from consumers, as is the case in the U.S. State of California.
OEMs also use door–to-door pickup as a mechanism for take-back of their own products. Business customers, and in some cases consumers, make a request to an OEM for pick-up of used equipment. The OEM then works with a logistics provider to pick up the product and deliver is straight back to the OEM or their appointed recycling partner for disposition.

5.2.3 Policy options

Policymakers have a number of potential options to encourage improved separate collection, which leads to more reuse and better recycling outcomes. These options are not mutually exclusive, and they can be used in any combination that suits the requirements of the country.

Establishing collection targets

One of the most fundamental tools of e-waste collection is the establishment of a collection target that is both realistic and achievable. There is a huge variety of potential ways in which the target can be set as well as potential variation in who is responsible for meeting the designated target.

There are three main ways in which collection targets can be set. The best option for a given region will depend on the information available, the maturity of the system, its socio-economic setting and complexity, as well as the current availability of recycling infrastructure.

Table 8 Comparison of key collection target methodologies

	Per capita target	% of product placed on market	% of e-waste arising
Definition	Set a specific amount of e-waste that needs to be collected per person. Target is number of people multiplied by the proposed target.	Based on the recorded volume of products placed on the market in year A. A target is then set for year B that is a percentage of the volume in year A.	Based on the estimation of the total volume of e-waste that arises in a country. A percentage is then chosen depending on the ambition of the program.
Responsibility	Government or third party organization	Government, third party organization or producers	Government or third party organization or producers
Pros	• Simple to calculate	• Uses market data which is generally required to be reported under most take-back systems	• Best able to incorporate market dynamics • Can account for technological changes (e.g., CRT to LCD TV) • Incorporates customer behaviour into target • Provides a "real" picture of what is available for collection
Cons	• Bears no relation to actual product Volumes	• Difficult to estimate lifecycle of products and when they will arise as e-waste • Cannot take account of markets that are either in growth or decline • Cannot account for technology substitutions, e.g., the move from heavy CRT to relatively light LCD TVs • Cannot account for different consumer behaviour regarding purchasing, repairing and storing.	• Most complex to calculate

Countries taking the first steps in establishing take-back systems should not believe that merely setting a high target would achieve the desired results. Any targets should be developed collectively with all stakeholders then monitored, improved and adjusted where appropriate. An important step that needs to be taken prior to setting a target is creating an adequate market survey to understand the volume of product being placed on the market, their use lifecycle and the volumes of e-waste arising across the various streams.

Effective measurement of collection volumes

Another hurdle for system designers and policymakers is to understand how to measure whether the target has been achieved or not. There is a tendency, with the EU being a prime example, to focus only on product collected through officially-sanctioned channels. However, as was noted in Section 4.2.2 above, there are many channels that fall outside of the government and producer systems. Although the amount varies amounts outside official channels vary wildly between countries, Figure 8 provides an example from the Netherlands that shows just how much product can go through unofficial channels.

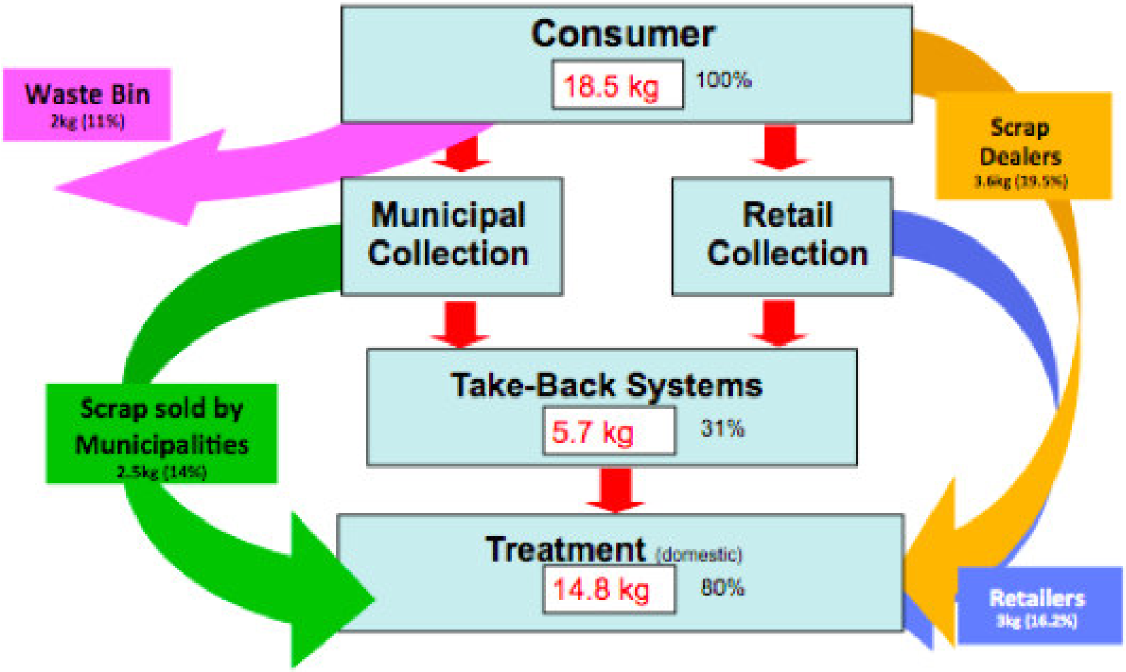

Figure 8 Learning from the flow of e-waste in the Netherlands

Source: Jaco Huisman, Future Flows

In this example, success was measured by solely counting the volumes accounted for in the take-back systems box, as is currently the case in the Netherlands. This situation gives the impression that only 31 per cent of the potential e-waste that is arising is being captured and properly treated. However if, all flows are taken into account, either by requiring all entities engaged in collection to report volumes captures or with success being measured at the point of treatment, then it appears that 80 per cent of the available e-waste was properly treated. This example illustrates how vital it is to consider where in the system is the most appropriate place to conduct the measure of success.

Collection Obligations of Municipalities

It is seen as a good practice in certain EU countries and North American States and Provinces to have municipal waste collection centres to provide consumers the opportunity to drop off, for free, their e-waste for processing. Although there may be a cost involved to the municipality for providing this service, it can be offset by raising funds to cover these costs from producers through regulatory systems or consumers either at point of purchase or at point of disposal.

While some countries do not have established waste collection networks managed at the local government level, the creation of such a network to tackle the e-waste problem, where the site can raise money from the e-waste collected, could potentially help establish facilities where other categories of waste can eventually be dropped off as well. It is important to note, however, that other types of waste should not be cross subsidised by the producers and consumers of EEE, even if they are collected at the same sites.

Collection obligations of retailers, distributors and producers:

Another policy tool that has proved effective in many jurisdictions is to make those actors responsible for selling products to pay their part in the collection system.
There are two generally accepted levels of obligation that can be placed on these actors. Firstly, there can be an obligation that whenever a new product is bought from a retailer, the customer, be they a consumer or a business, can return an equivalent product to the party selling the new product. This is generally referred to as "one-for-one" collection, and it is a common obligation within jurisdictions that have an e-waste management system.
The second option goes much further; rather than linking the disposal of e-waste to the purchase of new products, it forces all those who sell EEE to act as permanent collection locations for e-waste. This is generally implemented with a size threshold, so as to not disproportionately impact small shops.
There may be no need to implement such obligations in situations where the e-waste retains value, as retailers would be happy to receive the items, as is the case with mobile devices and wireless companies.

Disposal bans

A final option available to policymakers is that of enacting decrees that ban the disposal of e-waste with the general household or business waste. This has been the case in the EU WEEE legislation, where there has been total prohibition on disposing of e-waste with general municipal waste. Some U.S. states, like Massachusetts, have enacted ban on landfill disposal of cathode ray tubes only[85].
This policy option can be an additional method to try to inhibit people from disposing of appliances, especially small appliances, along with their normal household waste, the capture of which has proven to be a problem for many take-back systems. It should not be seen as a panacea for what is often quite an intractable problem, but it should be used to provide a clear message to people and companies that separation of e-waste at time of disposal is essential.

5.3 Appropriate recycling

5.3.1 Why this policy area is important

Recycling basically consists of recovering materials from discarded equipment and returning these materials to the manufacturing process. It is different from reuse, which consists of repairing whole equipment or components so as to extend their lifetime. The recycling of a computer, for instance, implies full dismantling of the equipment to recover mainly metals and plastics.
Incineration, especially open-air incineration as opposed to incineration in an incineration plant properly equipped with filters and controlling systems, as well as landfilling are considered hazardous treatment options for e-waste.
Open-air incineration of e-waste is clearly the most dangerous and inappropriate management option. A research team has investigated the presence of trace metals around the largest e-waste recycling site in Ghana, the Agbogbloshie market in Accra. At this large, informal market, used computers, monitors and televisions are dismantled and burnt or disposed of. Korle

Lagoon, in the nearby estuary, has become one of the most polluted areas on earth because of these practices. The research team collected and analysed mixed soil and ash from the market site. They found extremely high concentrations of copper (50 to 22000 mg/kg), zinc (200 to 160000 mg/kg), lead (100 to 14000 mg/kg) and tin (<50 to 1000 mg/kg), all of which exceed safe levels for human exposure. They concluded that "it is clear that soil/ash mixture has significant negative effects on human health"[86].

Another study carried out through soil, air and other environmental tests at a school, a church, a soccer field and a market near Agbogbloshie found out that levels of eight metals (iron, magnesium, copper, zinc, cadmium, chromium, nickel and lead) were up to 50 times higher than in uncontaminated areas[87].

Incineration of e-waste in sophisticated incineration plants in developing countries is less harmful but is still not a 100 per cent recommendable option, notably because of its high cost and the loss of valuable resources.

Table 9 Comparison of impacts of treatment options

Treatment option	Recycling	Incineration	Landfilling
Possibility to recover valuable materials	✓ Optimal	✗ Almost non-existent, except for some metals	✗ Non-existent, except in the case of an open-air dumpsite with informal waste pickers, which poses health problems.
Contribution to climate change (emissions of GHG)	✓ The GHG impact of recycling is minor compared to the GHG emissions avoided from recovering secondary materials to offset extraction of virgin materials. ✓ Manual dismantling of e-waste is ideal.	✗ Burning e-waste, notably the plastic parts that are derived rom petroleum, emits GHG emissions.	✗ In the case of e-waste, landfilling has no impact in terms of GHG emissions.
Other environmental impacts	✓ By avoiding the extraction of virgin materials, e-waste recycling avoids many forms of contamination due to the extractive industry (e.g., use of acids in mining).	✗ Not all waste disappears by burning; the ashes that remain after burning generally represents from one-third to one-fourth of the initial volume and quantity which then need to be disposed of.	✗ Almost all landfills leak. The liquid coming out of the wastes, called "leachate", may contain heavy metals and other toxic substances. ✗ Uncontrolled fires often occur in landfills, which can release toxic fumes.
Cost	✓ Can be low in the case of manual dismantling by informal workers. ✗ Quite high when dismantling and pre-processing are done in properly-equipped plants with decent working conditions, and when recycling occurs in specialized plants. But, the net cost depends on the e-waste type and value recovery potential.	✗ Quite high in the case of incineration plants equipped with filters and gas/ashes treatment systems.	✗ Quite low in appearance as the operation costs of a landfill are not very complicated, but the decontamination of the environment in case of leakages can be very costly in the long run.

Treatment option	Recycling	Incineration	Landfilling
Income generation	✓ Possible, through the selling of recovered materials, in particular metals and precious metals.	✓ Possible, through the selling of energy produced if the incineration plant is equipped with heat-recuperation devices.	✗ No income can be generated from disposing of WEEE in landfill.

Hazardous nature of informal recycling

Recycling activities are widespread around the world. In developing countries, there is a large informal sector that collects scrap metals and e-waste and manually dismantles the e-waste to improve the ability of recovering valuable metals. The techniques used by actors in the informal sector to recover recyclable materials often cause contamination. Some of the forms of unsound recycling, such as acid baths or open-air burning, pose serious threats to health and the environment. For instance, open-air burning of cables from various products to recover the valuable copper wire contained inside the PVC coating is a common practice in Ghana, Serbia and the Pacific Islands at time of publication[88]. It has serious impacts on the health of the informal workers, because burning PVC releases hydrogen chloride, which forms hydrochloric acid once in the lungs, causing acute respiratory problems for workers who inhale the gas.

Further environmental damage can be caused by disposal of the non-valuable material. Driven by poverty, primitive e-waste recyclers tend to recover only valuable parts and simply dump away the non-valuable parts. This practice is known as "cherry-picking", since it takes the most valuable parts and leaves the burden of managing the rest to another entity. Cherry picking is also common in the formal sector, as any private actor will seek to recover maximum value from e-waste as a priority above environmental considerations, except those highly concerned about environmental issues.

Design and production are global, but the e-waste challenge is first and foremost local

The design and production of EEE is so globalized that one could think that, since the same appliances are sold around the world, the social and technical challenges of e-waste recycling is the same for all countries as well.

Yet when comparing Switzerland, "the first country to implement an industry-wide organized system for the collection and recycling of electronic waste" and India, which has "a large recycling industry and (...) a major market for old and junked computers"[89] shows that the challenges to properly collect and recycle e-waste are completely different in developing and developed countries.

Table 10 Comparison between Switzerland and India with regards to e-waste generation and recycling

Criterion	Switzerland		India	
	Level	Implication	Level	Implication
E-waste per capita	High	Negative	Low	Positive
Employment Potential	Low	Negative	High	Positive
Occupational Hazard	Low	Positive	High	Negative
Emissions of Toxics	Low	Positive	High	Negative

Source: Sinha-Khetriwal, D., 2005.

For instance, in India, its mainly manual and informal e-waste recycling system creates income for more people per tonne of e-waste processed (10,000 informal e-waste collectors and recyclers work in New Delhi alone) than the high-tech Swiss

system (where there are 470 employees of the main company in charge of all operations)[90]. But the working conditions and level of social protection received by the workers are completely different.
In developing countries, collection and recycling are mainly done by the informal sector, recycling statistics are not readily available, the lifetime of most EEE in is generally longer than in industrialized countries and repair and reuse is more prevalent, further extending product life[91]. Although more low cost equipment is being imported to developing countries, especially from Asia, consumers are more willing to buy second-hand equipment.

Because of these differences, it is impossible to provide one list of policy options for all countries. The authors of the report chose to focus on policy options for developing countries, as that is where recycling is most widespread, but it also comes with higher environmental and human health impacts.

5.3.2 Policy options: from local recycling technologies to state-of-the art recycling technologies

State-of-the art recycling technologies are "recycling operations that employ the best available technology in industry, which has proven to meet environmental legislation (European standard), which can show that high resource efficiency is obtained via scientifically-proven mass balances, and which can show the final fate of its by- and waste products"[92].

Sidebar 2 The three steps of e-waste recycling

Step 1: Collection (see previous chapter)
Step 2: Pre-processing
- De-pollution, which consists of removing hazardous parts, such as lead glass from CRT displays, CFC gases from refrigerators, light bulbs and batteries[93].
- Manual disassembly to recover materials from complex fractions instead of or prior to mechanical shredding.
- Shredding, also known as mechanical processing, consists of cutting the used equipment into small pieces so that material separation can be more easily achieved. This implies some specific machineries such crushing units, shredders, magnetic- and eddy-current- and air-separators, as well as systems to filter and treat gas emissions and liquid effluents.

Step 3: End-processing
This final step consists of refining. It applies to metals, plastics and glass that are conditioned according to the requirements of the manufacturing industry interested in buying these secondary materials[94].

Refined materials can then be utilized in the production of new goods.
The following sub-sections focus on the available options to improve the practices of manual and semi-industrial dismantling of e-waste.

5.3.3 How to identify the local demand for recyclable materials and the technical requirements necessary from those materials

E-waste contains many valuable parts, especially metals and precious metals, but also plastics, for which there is generally a demand either from the local manufacturing industries or from exporters. This does not mean that locally dismantled, pre-treated, sorted, valuable parts or materials will be automatically bought by an end-processor. The industrial plants that are able to process metals or plastics might have technical requirements[95] that bar the materials in the

state they are recovered from EEE, depending on the specific machines they use. For instance, copper may have to be separated from steel before an end-processor is willing to buy it, because these two metals cannot be recycled together.
To actually be of interest to end-processors, recyclable materials may have to be:

- as pure as possible, which implies that they should have been well-separated from other materials that can impede the recycling process from a chemical or a mechanical point of view;
- conditioned in a way that they can easily be transported and used in manufacturing industry, which could involve shredding them into pieces of a precisely-defined size;
- sent in large quantities, which also reduces the cost of shipping in containers; or
- presented as non-shredded fractions. For instance, some end-processors desire entire, non-shredded mobile phones as the precious metal content can be reduced in the shredding process by dust generation.

The recyclability of materials does not only depend on technical factors but also on economic factors and, oftentimes, a combination of both.

5.3.4 How to identify hazardous parts in e-waste and what to do with them

Despite legislation in some countries (such as the RoHS Directive in the EU), and the voluntary efforts of the industry to change the design of EEE, there are still many hazardous substances in components of EEE. In fact, all e-waste is potentially hazardous waste if improperly handled, treated, incinerated or dumped.
The continuous change in the composition of EEE is one reason researchers must continuously investigate the potential hazardousness of new materials and substances that can find their way into EEE, and then communicate the results to public authorities who can then alert the private sector, recyclers and consumers. In the EU since the introduction of REACH regulation in 2007, the industry has been directly responsible for testing the toxicity of the chemicals contained in its products[96]. The following abridged table presents the most common hazardous parts in EEE and the recommended treatment options.

Table 11 Hazardous Products and Parts their treatment options

Hazardous material	Recommended destination
Batteries	Dedicated facilities for the recovery of cobalt, nickel, copper and lithium[97]. There are a very limited number of such facilities in the world.
Refrigerators and air-conditioners, as they contain cooling gases (CFC and HCFC)	De-gassing facilities, most of them based in industrialized countries
Monitors and TV screens, as they contain hazardous coatings in the panel glass (CRT screens) and mercury (backlighting tubes in LCD monitors)	Specialized plants, mainly based in developed countries
Compact Fluorescent Lamps (CFL) that contain mercury	Specialized plants, mainly based in developed countries
Circuits boards, as they contain lead (in the solders) and flame retardants (in the resins) *Note*: circuits board also contain valuable fractions such as precious metals that can be sold at high prices.	Integrated metal smelters, which recover precious metals, copper and other non-ferrous metals, while isolating the hazardous substances. There are a very limited number of such facilities in the world

Source: adapted from STEP (UNEP & UNU), 2010, Recycling - From E-Waste to Resources.

5.3.5 How to identify valuable materials in e-waste and what to do with them

Table 12 Best destination for various metals

Valuable parts	Recommended destination
Iron and steel (ferrous metals)	Steel plants
Aluminium	Aluminium smelters
Circuit boards, mobile phones and other precious metal-containing fractions	Integrated metal smelters, which recover precious metals, copper and other non-ferrous metals, while isolating the hazardous substances.
Copper	Copper smelters

Sources: adapted from STEP (UNEP & UNU), 2010, Recycling - From E-Waste to Resources and STEP, 2013, E-waste Country Study- Ethiopia.

5.3.6 E-waste recycling, a local or a global business?

E-waste recycling is currently a very globalized sector.

Typically, in developing countries where there is a large informal sector and low labour-force costs, the collection and manual dismantling (then unfortunately followed by unsound hazardous recycling and value generation practices) is very common. There is even a formal or informal local recovery and recycling of some metals such as iron, steel, copper and aluminium.

Integrated and complex metal and precious metal-containing components and fractions, such as circuit boards and cell phones can best be recycled by high-tech facilities, such as "integrated metal smelters". Likewise, batteries should be routed to specialized battery recycling plants that have the capabilities to recover with highest existing efficiency the material and value content. Such facilities are very limited globally and located mainly in industrialized countries.

This makes sense from an eco-efficiency and economical perspective, as these specialized plants with high-level equipment require heavy investments (several hundred million euros) [98] and require dealing with very large volumes of materials to be profitable. From an environmental point of view, although there are Carbon Dioxide emissions that result from the transportation of precious metal-containing e-waste fractions around the globe, it is still more eco-efficient than producing primary raw materials from mines. From a social point of view, this international division of labour can cover high tech, skilled jobs in industrialized countries as well as local labour-intensive manual collection and dismantling/pre-treatment jobs in developing countries.

It is therefore advisable that developing countries should give priority to the following investments:

- the repair and reuse sector, so that the equipment provides benefits to as many consumers as possible while creating local jobs;
- proper training on manual dismantling techniques and follow up with informal and small-scale operators on the use of these techniques;

- networking and collaboration with the end-processors as potential buyers of materials recovered from manual dismantling; and
- support for export processes and related administrative work in order to create maximum value recovery and financial flow back to the country from end-processors.

The "Best of 2 Worlds" approach [99] suggests that developing countries (continue to) develop labour-intensive manual dismantling locally, providing job opportunities via low-tech investments. Manual dismantling is more environmentally and economically efficient than mechanical dismantling, because mechanical dismantling requires advanced technology, high energy consumption, high investment costs and has a lower yield of material liberation and pure fraction separation potential. Developing countries also should enable shipments of recovered materials to global expert end-processor facilities, where the overall detoxification and recovery of valuable materials is most efficient and state-of-the-art. This approach considers that utilizing the existing end-processing infrastructures globally as attractive to developing countries in terms of providing economies of scale technology and infrastructure and being the most economically viable for the developing country's value recovery stream.

Case Study 9 Ethiopia, refurbishing other countries' used EEE or looking for sustainable solutions for its own e-waste?

The Ethiopian Ministry of Communication and Information Technology (MCIT) has set up a "Demanufacturing Facility (DMF)" which collected 17,162 devices such as computers, typewriters, printers and copy machines from federal government offices between October 2011 and December 2012. The collected devices have been partly dismantled and the DMF is currently searching for downstream markets and solutions for end processing of the various output fractions (e.g., steel, aluminium, cables, printed wiring boards, plastics)[100] against value.

5.3.7 The advantages of manual dismantling to achieve high recovery of valuable materials

Studies have shown that in order to reach the highest recycling rate of gold in PCs, the best scenario is to combine the maximum level of detailed manual dismantling with state-of-the-art refining for gold-rich disassembly fractions. A yield of 95.3 per cent of the gold contained in PCs is recycled in China using this method, whereas the mechanical pre-processing in Germany allowed a yield of only 51 per cent of the gold[101].

Sidebar 3 How much time does it take to dis-mantle e-waste?

The average time necessary to dismantle an old PC of 20 kg is 20 to 25 minutes, which represents a cost of 8 € (average wages + 30% of the average wages to reflect non-labour costs) in an industrialized country like the UK.
Other e-waste such as household appliances and TVs are considered less complex to dismantle and take only half the time necessary to dismantle a computer[102].
Mobile devices do no need dismantling, apart from the removal of the battery, for end processing, unless due to data security requirements.

Until recently, most public policies and private initiatives in developing countries have focused on attracting flux of second-hand equipment to refurbish it and sell it on their national market. However, e-waste streams are increasing quickly, so it has become urgent for developing countries to work on solutions for managing these streams, such as raising awareness, and training their local recyclers on environmentally-safe collection and dismantling practices.

5.4 Appropriate disposal

It has to be recognized that despite all efforts, there will always be some remaining material fractions of e-waste that cannot be reused or recycled and that might have to be disposed of by incineration or landfill. The challenge is then to improve the conditions of the safe disposal of the remaining waste.

Why landfilling and incineration should be avoided

The scheme presented in Figure 9 shows that landfilling and incineration represent an economic and environmental loss, or at best, a very limited potential environmental gain in the case of incineration. It therefore illustrates why neither landfilling nor incineration are satisfactory solutions to treat e-waste, even though some final fractions may require final disposition in one of these two ways. In the case of a desktop computer, this scheme shows that the better option for the highest environmental and economic gains is manual dismantling and recycling in a state-of-the-art facility.

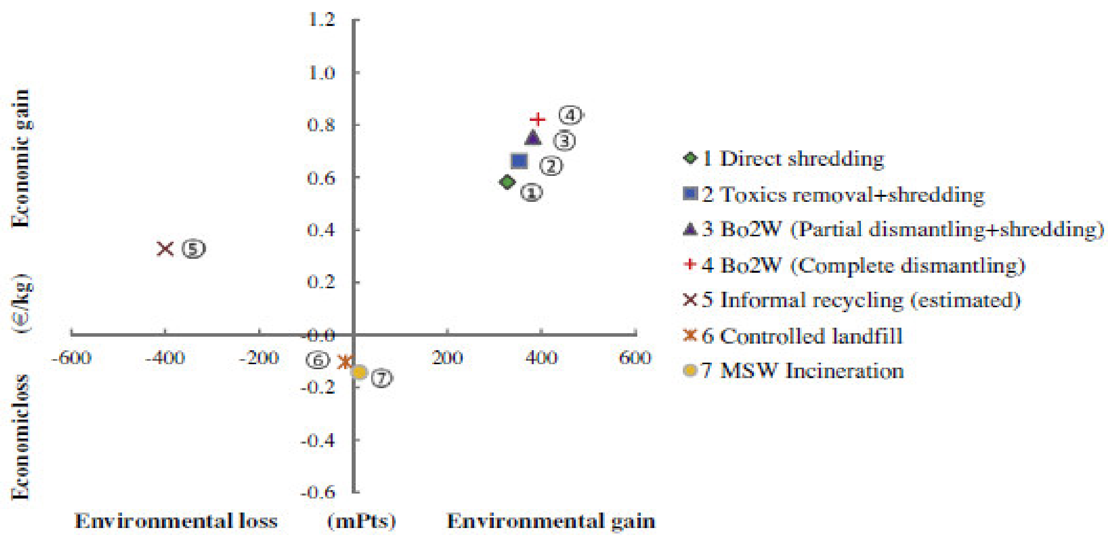

Figure 9 Comparison of the environmental and economic gains and losses of several treatment options for a desktop computer (based on 2010 price level)

Source: Wang et al., 2012

The International Labour Organization compiled the list below of e-waste compo-nents containing hazardous substances, which is presented in Table 13. The list highlights that these components should be treated with particular attention, and stresses that they should not end up in a landfill or an incinerator mixed with other types of waste.

Table 13 Hazardous chemicals contained in some e-waste

Chemical	Source in electronic products	Health concerns
Antimony	CRTs, printed circuit boards, etc.	Very hazardous in event of ingestion, hazardous in event of skin and eye contact, and inhalation. Causes damage to the blood, kidneys, lungs, nervous system, liver and mucous membranes (Material Safety Data Sheet, 2005)
Arsenic	Used to make transistors	Soluble inorganic arsenic is acutely toxic and intake of inorganic arsenic over a long period can lead to chronic arsenic poisoning. Effects, which can take years to develop, include skin lesions, peripheral neuropathy, gastro-intestinal symptoms, diabetes, renal system effects, cardiovascular disease and cancer (WHO, 2010b)
Barium	Front panel of CRTs	Short-term exposure causes muscle weakness and damage to heart, liver and spleen. It also produces brain swelling after short exposure (Osuagwu & Ikerionwu, 2010)
Beryllium	Motherboards of computers	Carcinogenic (causing lung cancer), and inhalation of fumes and dust can cause chronic beryllium disease or beryllicosis and skin diseases such as warts (Osuagwu & Ikerionwu, 2010)
Cadmium	Chip resistors and semiconductors	Has toxic, irreversible effects on human health and accumulates in kidney and liver (op. cit.). Has toxic effects on the kidney, the skeletal system and the respiratory system, and is classified as a human carcinogen (WHO, 2010c)
Chloro-fluorocarbons (CFCs)	In older fridges and coolers	Found to destroy the ozone layer and is a potent greenhouse gas. Direct exposure can cause unconsciousness, shortness of breath and irregular heartbeat. Can also cause confusion, drowsiness, coughing, sore throat, difficulty in breathing, and eye redness and pain. Direct skin contact with some types of CFCs can cause frostbite or dry skin (US. National Library of Medicine, n.d.)
Cobalt	Rechargeable batteries and coatings for hard disk drives	Hazardous in case of inhalation and ingestion, and is an irritant of the skin. Has carcinogenic effects and is toxic to lungs. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005)
Copper	Used as a conductor	Very hazardous in case of ingestion, in contact with the eyes and when inhaled. An irritant of the skin and toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005)
Dioxins	Created when electronics are burnt in open air	Highly toxic and can cause chloracne, reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer (WHO, 2010d)
Gallium	Integrated circuits, optical electronics, etc.	Hazardous in case of skin (may produce burns) and eye contact, ingestion and inhalation. Severe over-exposure can result in death. Toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005)
Hexavalent chromium	Used as corrosion protection of untreated and galvanized steel plates and a decorator or hardener for steel housings (Osuagwu & Ikerionwu, 2010)	Damages kidneys, the liver and DNA. Asthmatic bronchitis has been linked to this substance (Osuagwu & Ikerionwu, 2010). Causes irritation of the respiratory system (asthma) and skin, liver and kidney damage, increased or reduced blood leukocytes, eosinophilia, eye injury, and is a known carcinogen (lung cancer)
Indium	LCD screens	Can be absorbed into the body by inhalation or ingestion. Is irritating to the eyes and respiratory tract and may have long-term effects on the kidneys. Environmental effects have not been investigated and information on its effects on human health is lacking; therefore utmost care must be taken (ICSC database, n.d.)

Lead	Solder of printed circuit boards, glass panels and gaskets in computer monitors (Osuagwu & Ikerionwu, 2010)	Causes damage to central and peripheral nervous systems, blood systems and kidneys, and affects the brain development of children (Osuagwu & Ikerionwu, 2010). A cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems (WHO, 2010e)
Lithium	Rechargeable batteries	Extremely hazardous in case of ingestion as it passes through the placenta. It is hazardous and an irritant of the skin and eye, and when inhaled. Lithium can be excreted in maternal milk (Material Safety Data Sheet, 2005)
Mercury	Relays, switches and printed circuit boards (Osuagwu & Ikerionwu, 2010)	Elemental and methyl-mercury are toxic to the central and peripheral nervous system. Inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested (WHO, 2007)
Nickel	Rechargeable batteries	Slightly hazardous in case of skin contact, ingestion and inhalation. May be toxic to kidneys, lungs, liver and upper respiratory tract. Also has carcinogenic effects (Material Safety Data Sheet, 2005)
Perfluorooctane sulfonate PFOS/F)	Photoresistant and anireflectant coating	Persistent, bioaccumulative and toxic to mammalian species; linked to increases in the incidence of bladder cancer (OECD, n.d.)
Phthalates	Used to soften plastics	Disrupts the endocrine system, reproduction, fertility and birth, and has developmental effects. Also has organ system toxicity and is linked to liver cancer and effects on the brain, nervous system and immune system (Environmental Working Group, n.d.)
Polybrominated diphenyl ethers (PBDEs) used in brominated flame retardants (BFRs)	Plastic housing of electronic equipments and circuit boards to reduce flammability (Tsydenova & Bengtsson, 2011)	PBDEs are of concern because of their high lipophilicity and high resistance to the degradation processes. Hepatotoxicity, embryotoxicity and thyroid effects seem to be characteristic endpoints in animal toxicity, and behavioural effects have been demonstrated (Darnerud, Eriksen, Jóhannesson, Larsen, & Vileksela. 2001). BFRs in general have been shown to disrupt endocrine system functions and may have an effect on the levels of thyroid stimulating hormone and cause genotoxic damage, causing high cancer risk (Tsydenova & Bengtsson, 2011)
Polychlorinated biphenyls (PCBs)	Insulating material in older electronic products	Linked to reproductive failure and suppression of the immune system (Stockholm Convention, n.d.)
Polyvinyl Chloride (PVC)	Cabling and computer housing plastics contain PVC for its fire-retardant properties	Produces dioxins when burnt; causes reproductive and developmental problems, immune system damage and interferes with regulatory hormones (Osuagwu & Ikerionwu, 2010)
Silver	Wiring circuit boards, etc.	Very hazardous in case of eye contact, ingestion and inhalation. Severe over-exposure can result in death. Repeated exposure may produce general deterioration of health by an accumulation in one or many human organs (Material Safety Data Sheet, 2005)
Thallium	Batteries, semiconductors, etc.	Very hazardous in case of ingestion and inhalation. Also hazardous in case of skin and eye contact. May be toxic to kidneys, the nervous system, liver and heart, and may cause birth defects. Severe over-exposure can result in death (Material Safety Data Sheet, 2005)
Tin	Lead-free solder	Causes irritation in case of skin and eye contact, ingestion and inhalation. Can cause gastrointestinal tract disturbances, which may be from irritant or astringent action on the stomach (Material Safety Data Sheet, 2005)
Zinc (chromates)	Plating material.	Contact with eyes can cause irritation; powdered zinc is highly flammable (University of Oxford, 2005); if inhaled, causes a cough, and if ingested, abnominal pain, diarrhoea and vomiting is common (ICSC database, n.d.)

Source: ILO, 2012.

In short, e-waste contains heavy metals (e.g., copper, zinc, cadmium, mercury, etc.), which can cause degenerative diseases in living organisms (e.g., Parkinson, Alzheimer), blood, mental or nervous system problems when present in excessive concentration.

What happens to e-waste in a landfill?

Even the landfills equipped with special layers to prevent the contamination of the soil and groundwater through leaching of liquid substances are not completely watertight. Mercury from destroyed printed circuit boards, PCBs from condensers, polybrominated diphenylethers (PBDEs) from plastics and printed circuit boards, lead from cathode ray tubes and cadmium contained in some plastics may leach into the soil and groundwater. Vaporisation of mercury from broken lamps or other components in e-waste can also contribute to the spread of this heavy metal in the environment[103].

What is a landfill ban?

The complex and toxic nature of e-waste should lead policymakers to consider it as something other than "final waste". For instance, not taking into consideration ie-waste ignores the fact that 70 per cent of the heavy metals found in landfills in the United States come from e-waste[104].
In fact, in Australia and in some U.S. states, e-waste landfill bans have been introduced in legislation[105]. This means that separate collection is mandatory, and that e-waste should be handled by specialized recyclers. However, non-recyclable parts of e-waste can still be ultimately disposed of under these schemes. In the EU, a specific directive applies to landfill management[106].

5.5 How can we ensure an environmentally-sound disposal of e-waste?

5.5.1 Minimal specifications for environmentally-safe landfilling

Waste, including e-waste and its hazardous components, is still disposed of in uncontrolled dumpsites or dumped in the streets or into the ecosystem in the countries that have yet to find solutions to manage it efficiently, which poses tremendous environmental problems as well as health problems due to the uncontrolled contamination of air, soil and water.

An environmentally safe landfill is one that applies the 4Cs: confine, compact, cover and continuously monitor[107].

This implies:

- proper confining of waste, or impeding direct contact of the waste with soil, so as to prevent infiltration of toxic liquids coming out of waste and contaminating groundwater (this can be done by placing plastic liners at the bottom of the landfill, and by installing leachate drains);
- proper compacting of waste to prevent fires;
- proper covering of waste with soil and even vegetation, if possible; and
- continuous monitoring to ensure the integrity of the landfill.

There should also be a buffer area, ideally with tree plantations or other vegetated spaces surrounding the landfill zone. Additional environmental benefits can be derived if gas capture devices are installed as part of the landfill to avoid methane release from the decomposition of organics that can contribute to climate change.

5.5.2 Incineration of plastics from e-waste in cement kilns: not an advisable option

Cement kilns are found around the world. Because kilns require significant amounts of fuel during processes, its operators are sometimes interested in buying waste, even e-waste, to burn as a substitute for oil. They claim that as the kilning stage (combustion) requires very high temperatures, higher than in usual incineration plants for municipal solid waste, it is safer for the environment as it destroys hazardous fractions, brominated flame retardants (BFRs) in particular, and it prevents the emissions of dioxins and furans[108].
However, it is also acknowledged that this practice is not advisable:

- for sanitary reasons
  - In Ethiopia, when Africa Stockpiles Programme (ASP) investigated the possibility of disposing of e-waste plastics in cement kilns in 2006, they found that about 4 per cent of all materials put into kilns leak out. Also, the operation condition for the kilns is supposed to be at low oxygen levels (of 3 to 4 per cent), which is impossible to maintain, implying that the complete incineration of hazardous fractions does not occur. Also, ASP found that the weak regulations and insufficient capacities do not allow proper monitoring of such operations in Africa[109].
- and for cost reasons
  - Gasification might be safer for the environment than incineration and landfilling, but it is more expensive[110]. Developing countries may not be able to afford such investments, especially when the safety for the environment is not 100% proven.

Rather than being sold to cement kilns, plastics containing BFRs can be recycled back into plastics used in EEE. A photocopier manufactured by a Japanese company that contains 30 per cent of recycled BFR plastics in its outer housing is already available[111]. In the absence of such plants in developing countries, it is more prudent to dispose of these plastics in landfills engineered for hazardous waste.

6 Financing: Who should pay what

6.1 Why this policy area is important

A take-back system, with many stakeholders and actors as well as operations to perform requires a workable and fair financial and economic model if it is to be sustainable and function properly. It is therefore vital that policymakers, working with all key stakeholders engaging in this area consider how the financial model should be established to cover the collection sites and logistics along with the physical recycling itself. Along with these obligations, there is the need to raise awareness of the proposed system, ensure that stakeholders are complying with their obligations as well as setting up IT systems to receive and process the data.

The allocation of financial responsibilities among the relevant stakeholders, as well as their boundaries, requires substantial and sustained dialogue between government, producers and other relevant stakeholders. Many models exist, all with their own merits and issues.

6.2 Potential financial sources

From a general perspective, there are three relevant stakeholders groups with potential, individual or shared, responsibility for EoL EEE:

- The entire society. As e-waste can be seen as a societal problem, as it not only impacts consumers, but also the entire population (both in terms of environmental and societal impacts), systems could be financed by the entire society (i.e., by taxpayers).

  - This option would require general tax revenues to be diverted to meet the costs associated with the take-back system
- The consumers. This could be seen as an implementation of the “polluter pays principle”, where the polluter is recognized as the person responsible for discarding an EoL appliance.
  - This option would mandate that the consumer either pay to discard the product or pay a fee when purchasing the new product, which would be collected in a centrally-managed fund to meet the costs associated with the take-back system.
- The producers. This is through the implementation of varying forms of the “extended producer responsibility” principle. It could also be argued that even though a producer may bear financial responsibility, consumers will eventually pay the EoL costs as part of the product price, even when no up-front external charges are paid at point of sale.
- In this case, the producer can be best defined as “the local manufacturer or importer of record of new and used EEE to be placed on the XYZ market at first invoice by sale or donation” as explained in Section 2.3.2.
- This option would require producers to meet the costs associated with the solution. There are a number of ways in which the producer does recoup the costs from their customers, such as by increasing the sale price of the item.
  - It is also good practice to allow manufacturers, or their authorized representatives, to take over responsibility from the local importer where they have a local presence but are not legally responsible for the import of their products if they so wish. The local importer would retain producer responsibility, unless they could show proof that the manufacturer was taking over the responsibility
  - In this case, the “The Original Equipment Manufacturer” is the company that manufactures or assembles the original product under its own brand name. The OEM is also known as a “Manufacturer”.

In addition to potentially raising money from the stakeholders above who could pay fees or reimburse costs, it is important to note that considerable value can be generated from some of the return streams of e-waste through efficient reuse and recycling.

In order to minimize the amount of extra funds that need to be raised, collection sites and recyclers should analyse and separate equipment that they deem suitable for repair and reuse. These products could either be sold to professional repair operations or repaired in-house with all the profit going to meet some of the operational costs. Some e-waste types can be recycled at a profit, such as washing machines, mobile phones and some ICT equipment. Such products do not require additional financing in order to meet treatment costs, although depending on the system, the collection and other associated administrative tasks may still require some small amount of financing.

6.3 Who should receive and distribute payments?

There will be a need for finances to meet the additional costs in the case of the treatment of e-waste containing hazardous substances, such as cooling equipment, or where there is almost no resale market—and thus no value—for the extracted material, like CRT glass from televisions and monitors.

There are three principal organizations who could logically receive and administer the finances of the take-back system. Firstly, there is the local government agency that either deals with business, tax or even the environment. Secondly, a producer responsibility organization (PRO) could administer the finances. Finally, the finances raised could be transferred directly to recyclers.
When a PRO is used to organize compliance, actors should establish a financial reserve in the PRO that can be used in case a large manufacturer disappears from the market (bankruptcy) and is no longer able to pay for their obligated volumes of e-waste. If a financial reserve is not in place, this cost would suddenly fall on the PRO, which could result in bankruptcy of the PRO. Such a financial reserve should not exceed one year's turnover of the system.

Table 14 Pros and cons of the administration of the finances of the take-back system

	Government	PRO	Recyclers
Pros		• Helps ensure efficient use of resources • Impartial stakeholder	• Helps ensure efficient use of resources
Cons	• Potential for funds to disappear into general government revenue and not be used specifically for take-back activities	• Creates additional layer of bureaucracy	• Complex to administer

6.4 Policy Options

Based on the differences in the operational and financial structures of systems in place around the world, it is possible to define at least three generic financing models.

- The first model looks to set up-front fees to be paid by the producer when the product is placed on the market.
- Secondly, there is the model that makes the person or entity responsible for disposing of the e-waste financially liable for the cost of the collection and recycling.
- A third type uses market share financing models, which seek to recoup all the actual operational costs of running the take-back system.

6.4.1 Up-front fee models

In an up-front cost model, producers finance all activities in the system at the time of placing a product on the market. For example, this can be accomplished by joining a PRO, or by financing their own take-back system or collective compliance scheme.
In the majority of cases, producers join a PRO and pay their determined share of the costs for take-back and recycling programmes and all other services provided by the scheme. The cost could be based on the number of units sold or the total weight of products sold, and it is determined by the scheme on the basis of past recycling costs or estimation of future costs.
Schemes usually assess compliance costs on the basis of fees charged by treatment plants and logistics partners. The costs can and should be revised regularly in accordance with specific statements in the contracts between the compliance scheme and the producers.
The compliance cost model includes direct involvement of producers as stakeholder in the financing of the system.

Case Study 10 Up-front fee model in China[112]

The recently-enacted Chinese regulation on Management of the Recycling and Disposal of WEEE in 2011 marked the start of EPR responsibilities in the country. Under the regulation, producers of equipment covered by the legislation, in this case TVs, refrigerators, washing machines, air conditioners and computers, are required to pay a fee in order to be legally able to place products on the Chinese market. In this case, producers are defined as the entity placing the product on the Chinese market in accordance with the principle defined in Section 5.2. The fees are paid directly to the government-managed "specialized fund", which then distributes the money as required. The main distribution activity is to compensate registered recyclers for having treated covered products.
The fee structure for placing products on the market and the subsidy given to the recyclers for treatment are listed below:

	TV (CRT and flat panel)	REFRIGE-RATOR	WASHING MACHINE	AIR CONDI-TIONER	COMPUTER (desktop and laptop)
Producer fee (per unit sold)	RMB 13 / USD 2	RMB 12 / USD 1.9	RMB 7 / USD 1.1	RMB 7 / USD 1.1	RMB 10 / USD 1.6
Treatment subsidy to recycler (per unit treated)	RMB 85 / USD 13.5	RMB 80 / USD 12.7	RMB 35 / USD 5.5	RMB 35 / USD 5.5	RMB 85 / USD 13.5

The large discrepancy accounts for the fact that the Chinese government only expects a fraction of the products placed on the market to end up being processed by approved treatment facilities, due to the active informal sector. The government is keeping the level of the treatment subsidies under regular review.

Historical waste and Visible Fees

Since retroactive legislation is avoided as much as possible, there needs to be a mechanism for dealing with the products placed on the market prior to the legislation coming into force that will need to be treated under the established take-back system. This "historical waste" problem is generally solved by treating it as the collective responsibility of those actively placing products on the market.
One of the mechanisms developed to deal with historical waste is the introduction of the so-called "Visible Fee" which generates revenues from final users to cover waste management costs. The Visible Fee mechanism was originally introduced by the EU WEEE Directive as a means for producers to share the burden of financing historical waste with consumers. Producers are therefore allowed to share financial responsibility with consumers to cover the costs of historical waste. However, its use has been extended under the EU WEEE Recast, so that it is now also a mechanism for financing future e-waste.

When implementing a Visible Fee system, it is important to remember that this imposes a large burden on producers and/or retailers who then need to manage the fee structure and alter invoices or shop displays, so that customers can see the amount easily. To avoid inefficiencies and unnecessary administration, visible fees should be voluntary, and the only mandatory element should be that producers ensure that they pay the up-front fees to the relevant organization.

Case Study 11 Belgium and the Visible Fee

Belgium operates a take-back system via Recupel, as the PRO, which has a monopoly, because it is the only officially-authorised compliance scheme. For all consumer equipment under this system, a fee must be paid by the producer to the PRO to cover the administrative costs and paying collection points and recyclers for all associated activities with the EoL of the product. This model differs from the Chinese model, because producers are additionally required to show the amount of the fee on the customer invoice and have it displayed in shops alongside the price of the product. In this way, the producers are able to recoup the cost of the fee directly from the consumer in a transparent fashion.

For business products, a producer can either pay an administrative fee to the PRO that covers only the administrative tasks of reporting or submit an Individual Waste Management Plan to the government for approval. Under both systems, the producer then has to ensure that they perform all collections and treatment of their e-waste from business users at their cost.

The current price list can be found at: http://www.recupel.be/current-appliance-list.html

Analysis of up-front fee model

There are some positive aspects to the up-front fee model, as they are very simple to understand from a consumer perspective and to implement from a government perspective. However, there are also a number of issues with the up-front fee models that should be outlined.

Firstly, WEEE fees per product are very inflexible. Once a methodology is established, altering it and adapting to evolving product and market dynamics are very time-consuming. For instance, if collected WEEE volumes exceed the planned financial forecast, a shortfall could occur. Also, as noted in 5.4.1.1, making frequent changes can be burdensome for producers.

Secondly, many countries that operate up-front fee models have seen huge financial surpluses build up in the organizations that collect the funds from producers that come indirectly from consumers. This is as a result of the lag between a product being placed on the market, when a fee is collected, and when it needs to be recycled, which can vary greatly from months to more than 20 years in some cases. In addition, due to the difficulty in setting the correct price, initial prices have often been set at the high end of estimates.

Finally, any areas where the fee structure leads to a deficit, through a sudden increase in recycling costs or loss of a market opportunity to resell the output of recycling processes, it can often be problematic to fund these gaps, because most systems have a guarantee against one product type cross financing the recycling costs of other product types.

6.4.2 End-of-life fee

An EoL fee is paid by generators of e-waste (i.e., the last owner of a product who decides to recycle it) to an entity who assumes responsibility for recycling the e-waste at the moment that it is handed over to the recycler. The fee covers collection and recycling costs.

Case Study 12 Cost Recovery in Japan[113]

In the Japanese model, consumers are obligated to pay the necessary fees associated with the transport and recycling of the appliance for the covered products. Usually, consumers return their e-waste to the retailer they purchased the product from or where they are purchasing a new one. In some cases, the local municipality collection system can also perform this role. These retailers are allowed to charge collection and recycling fees to consumers. The retailers do not normally do the recycling and in general, they transfer the product to the manufacturer. Manufacturers are also allowed to charge the retailer for the actual costs of recycling the product. At each stage the ministry in charge, METI, may order a retailer or manufacturer to alter their fee if they consider the charge to be disproportionate.

Analysis of end-of-life fee model

Japan is the only country in the world to implement such a system, and as such, it provides the only example of the model. The Japanese model is also one of the oldest legally-binding systems in the world and has been in operation since 1998.

The advantages of the system is that funds are only given when an item actually needs to be recycled, and the costs will reflect the actual costs associated with treating the item. This ensures that there is no build up of huge surpluses by government of PROs. Conversely, there is a significant potential that implementing an end-of-life fee could act as a disincentive for the consumer to have the product recycled, since recycling fees in Japan vary from 2,400 to 4,200 Yen ($20-$46).[114] There is some evidence that the Japanese system is less efficient at collecting the large household appliances and cooling and freezing equipment than most EU countries. Whereas in the Netherlands shows a collection rate of 75 per cent for LHA[115] and 80 per cent for cooling and freezing[116] equipment based on the total amount of these items arising as waste, Japan only shows a collection rate of 50 per cent[117]. The remaining 50 per cent is either exported (18 to 26 per cent) or unaccounted for (24 to 32 per cent).

6.4.3 Market share fee models

The other major financing model approaches the issue from the opposite perspective. Rather than seeking to raise funds from producers as products are placed on the market to cover costs that will arise many years from then, market share models fund themselves retrospectively. What this means is that once the costs of administering the take-back system are known, and usually have been spent and invoiced, this fixed amount is then divided between the registered producers. This ensures that many of the issues raised above around fee flexibility, running surpluses and problematic deficits are all resolved.

The central issue for this financing model is then how to divide up the costs between the producers. Two principle models have evolved, one based on the products placed on the market and the other looking at the physical returns being received and understanding the respective market shares of the producers.

POM based market share models

A model is used to allocate the market share based on the volume of product placed on the market in a given timeframe, usually one year. In order to avoid cross-subsidisation, the market share is generally calculated either at a product or product category level.

The obligation on producers comes in two forms. Firstly, there can be a requirement to pay the relevant percentage of the total operating costs of the entity collecting and recycling the e-waste arising on their behalf. Alternatively, clearing houses (entities responsible for the allocation of responsibility between all the producers) can be established to arrange for the collection and recycling of the appropriate amount of e-waste arising.

Case Study 13 PRO in the Netherlands

All producers who sell products must be members of the PRO in the Netherlands. ICT producers had a specific PRO that they had to join, and under the scheme producers submitted an estimation of the total volume that they forecast that they would place on the Dutch market. The PRO then estimated the total costs that it would incur. Based on the figures submitted, the PRO assigned a specific financial obligation according to the market share. This market share, together with the estimation from the PRO, was then used to calculate an estimation of what each producer was responsible for paying. This money was paid at the beginning of the compliance year. At the end of the compliance year, actual costs and actual totals placed on the market were submitted and actual market shares calculated. These totals are then reconciled with the amounts already paid.[118]

Case Study 14 Germany allocation Model

Under the German system, a clearing house called Elektro-Altgeräte Register (EAR) was established to register producers and to allocate and coordinate the provision of containers to, and the collection and recycling of e-waste from, German municipal waste sites. Annual reports of the volumes placed on the market are submitted by producers over a given timeframe. Based on these reports, EAR allocates a specific market share to each producer. EAR then provides notification based on the calculated obligation to producers, or third parties acting on their behalf, of when and where they must both collect a specific load of e-waste and place a new empty container. This must all be done within a strict timeline, or fines may occur.

Returns market share models

An alternative is the concept of allocatingresponsibility based on return market share, which is one way of implementing IPR. This relies on random auditing of the e-waste that is being returned through the take-back system. This method is done at a product level or product category level. It requires that the system manager, either a government or PRO, record the brand and volume of each product in order to be able to calculate the percentage of the returns that each producer is responsible for.

Case Study 15 Maine Return Share Model

The U.S. state of Maine operated one of the only return share financing models in the world. This system was discontinued for most product types in 2010 with only monitors/TVs still operating under the model.

In this model, Maine calculated the relevant share of the financial responsibility that each producer had not by looking at what was placed on the market but by the relative volume in which the producer's brand appeared in the actual waste stream. The authorities achieved this by auditing the collected returns and meticulously recording the brand and weight of individual items. Importantly they only audited a sample of the returns and extrapolated from there rather than auditing all returns. Each producer was then required to pay to the local government based on their market share and the total cost of treating that product.

The models presented in this chapter do not represent the only solutions, but rather define fundamental approaches. Hybrid models of these approaches are possible. For example, a small up-front fee couple with the POM based market share to reconcile any missing funds for particular products.

Table 15 Pros and cons of different fee systems

	Upfront fee	Visible upfront fee	POM based market share	Return share	EoL fee
Pros	• Simple	• Simple • Transparent to consumer	• Only actual costs are raised • Specific for product types	• Only actual costs are raised • Most accurately assigns cost to producers causing most impact • Accounts for where product	• Simple • Transparent to the consumer

	Upfront fee	Visible upfront fee	POM based market share	Return share	EoL fee
				arises as waste and where product POM does not matter	
Cons	• Inflexible • Easily generates surplus • Difficult to address deficits when insufficient funds are raised for a specific product type • Need to account for e-waste collected through producer's own take-back systems	• Inflexible • Easily generates surplus • Difficult to address deficits • Creates additional administrative burden • Need to account for e-waste collected through producer's own take-back systems	• POM not necessarily reflective of actual share of recycling volume • Need to account for e-waste collected through producer's own take-back systems • For the first years, funding source needs to be identified as funding is retroactive	• In many countries, brand owner will not be the importer and therefore assigning responsibility to the correct party will be challenging • Requires additional work to perform auditing • Additional work means additional administrative cost • For the first years, funding source needs to be identified, as funding is retroactive • Producers are required to create financial provisions to cover the cost of recycling all their entire installed base.	• Potential to act as a disincentive to recycle • Major surpluses are raised

7 Controlling Transboundary Flows of E-waste

7.1 Why this policy area is important

Transboundary flows of e-waste have become a major concern for both the exporter and importer countries, for different reasons in recent years as there has been increased visibility of the negative impact for both parties. Growth in globalized trade and complex international product supply chains have developed in tandem with the growth of a global trade in e-waste and used equipment.

Although the exact volume of the flow of e-waste is almost impossible to measure, as a lot of it is exported illegally or under the guise of being for reuse or pretending to be scrap metal, it is widely accepted that the volume is significant. What is also not disputed is the direction and destination of the vast majority e-waste that is exported. The map below is a good representation of the largest of these flows but is by no means comprehensive.

Figure 10 Largest Global Flows of e-waste from developed to developing countries

One of the difficulties in this area is how to enable the beneficial trade in good quality used EEE to continue if it provides good quality affordable products for second-hand markets, can help bridge the digital divide and can provide a source of employment, while stopping the harmful export of e-waste that is beyond repair and that only contributes to harming both the natural environment and human health in the destination countries. By extension, the trade between high quality pre-processing and end-processing facilities should also be encouraged and often barriers put in place to reduce harmful cross border trade also impacts, through additional cost and delay, on this vital aspect of the e-waste recycling system.

Countries who receive large quantities of used equipment from around the world are suffering most acutely from this dilemma, since they are the ones who have to deal with the e-waste that is a consequence of this trade. Should they cut off the supply of used equipment in order to save the environment and protect the workers at informal recycling centres, but then also suffer because it will reduce the availability of low-cost, even free, used equipment for sale and repair, and therefore reduce the availability to their citizens of affordable electrical and electronic equipment? Indeed, different importer countries have different motivations for seeking out e-waste from other countries. In West Africa, the demand for products seems to be driven by a hunger for parts for the reuse market, whereas countries like China require products and e-waste to help meet an almost insatiable demand for certain raw materials [119]. Another driver can be exporters seeking to generate profit by dumping equipment for disposal and recycling into markets that cannot handle them properly.

There are a number of reasons why many exporter countries are increasingly trying to cut down on the volume of e-waste sent out of their countries for reuse or treatment. Although part of their reasoning is that they want to comply with enacted legislation and reduce the potential harm that these products do to the environment and human health, the debate has also taken on a new form in recent years. The interest lies in ensuring that valuable resources locked away in e-waste are not allowed to escape and be lost through non-existent or sub-optimal recycling processes.

At the heart of the area of global e-waste trade are the dual problems of consistent definitions together with drawing a clear legal distinction between second-hand goods for immediate reuse (without any additional processes), used products sent for repair and e-waste destined for recycling coupled with the problem of enforcement of the established rules that already render illegal some of the trade in e-waste that destined for recycling.

It is also important to note that although repair and reuse should be valued more than recycling in general, the global trade in used equipment for reuse and repair may not always be beneficial. This is because the process of repair generates e-waste itself. When this e-waste is generated in countries that do not have an environmentally-sound recycling infrastructure there is significant risk that the process will generate the harmful effects usually associated with the informal recycling sector.

What has also become clear, as the research has progressed, is that the potential value locked away in e-waste–be it as reusable product, a spare part or a desired resource–is a significant driver of this area of global trade[120,121].

7.2 Existing International Initiatives

7.2.1 Basel Convention

The principle international initiative that controls the movement of hazardous waste is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal that entered into force in 1992. As of March 2013, 179 countries are parties to the convention, and the United States, Afghanistan and Haiti the only countries to have signed but not ratified[122].

The principle foundation of the Basel Convention is that countries should seek to minimise the production of hazardous waste, that priority should be given to providing sound domestic waste management, and that there should be minimal transboundary movements of hazardous waste especially from developed to developing world. The "Ban amendment" to the convention goes further by banning all export of hazardous waste for disposal to a country listed in Annex VI of the convention.

It is vital to note that the Basel Convention does not ban the movement of hazardous waste but merely sets up a regime of notifications and approvals that need to be attained in order for the transportation to be legal.

The Basel Convention was designed to deal with the problem of more traditional hazardous waste streams and classifies things as hazardous depending on the chemical composition of the product rather than by product type. This means that the Basel Convention does not currently provide any clarity as to whether a particular computer or DVD player is either hazardous or non-hazardous. The result is that there are not always clear rules as to whether certain types of e-waste are covered by the convention or not.

There are a couple of very important initiatives being conducted under the Convention that look at specific product types and develop clearer rules to govern their transboundary movement. There have been two: one covering mobile phones (the Mobile Phone Partnership Initiative) and another, still in progress, looking at computers (the Partnership for Action on Computer Equipment).

Another very important initiative that is making good progress as of mid 2014 is the attempt to create a clearer guide to defining when a product becomes waste. This is a major multi-stakeholder initiative, which although complex, will greatly improve the consistency by which EEE becomes WEEE.

7.2.2 European Waste Shipment Regulations

Another key international initiative was launched in Europe because of the Basel Convention and resulted in 2006 in the Waste Shipment Regulations.

What types of waste can be exported depend on a number of factors, such as destination of the waste, the purpose of the export (i.e. reuse, recovery, recycling or disposal) and the nature of the waste being exported. The nature of the waste is divided into three distinct categories that are prohibited waste, notification controlled and green listed.

An important difference from the Basel Convention is that the EU Regulations list some of the components of e-waste and to which waste category they belong. However, many major components are not in the list, which leads to continued uncertainty about how certain products and components should be classified under the regime.

The Regulations firmly prohibit the shipment of hazardous waste from the EU to a non OECD country. They do, however, allow shipments of non-hazardous and functioning used equipment to other countries. The recently Recast WEEE directive (2012/19/EU) does, however, place additional burden on those wanting to export functional used equipment across national borders.

7.2.3 Bamako Convention

On January 30, 1991, the convention on the ban on the import into Africa and the control of transboundary movements and management of hazardous wastes within Africa was drafted and finally came into force in 1998. It was sought by African countries that had advocated for a complete ban on transboundary shipments of hazardous waste, but they failed to get it included in the Basel Convention.

Although there are many similarities the, Bamako Convention differs in a few key ways from the Basel Convention, some of which will be briefly outlined. The most important difference is that it sets out a total ban on the import into Africa of any hazardous waste. Secondly, it covers a wider category of wastes For example, it contains a provision ensuring that an item deemed hazardous in the country of manufacture will automatically be deemed hazardous. It also ensures that any contravention of the convection is a criminal offence.

Although marking an important milestone in the battle against African countries being seen a dumping ground for the developed world “a lot still needs to be done to turn these lofty symbolic ideals into substantive realities”. It is vital that more countries join and enforce the convention and also support Africa in tackling the issues of corruption and poverty, which can subvert the good intentions of the convention.

The parties to the convention help with first Conference of Parties in Mali in June 2013 showing a clear intention on the part of African nations to start to actively tackling the problem of transboundary waste within and into their continent.

7.2.4 OECD Guidelines

In 1992, the Organisation for Economic Cooperation and Development (OECD) developed their Waste Agreement with the aim of supervising and controlling transboundary movement of hazardous waste within the OECD area, focused mainly on items exported for the purpose of recycling. The OECD system diverges from the Basel Convention in the way that it categorises waste, reinforced in a decision by the Council in 2003, which differentiated between green and amber listed waste. Green waste, considered of minimal or no-risk, can be exported without additional controls, whereas amber waste, considered to pose a real risk to the health of humans and the environment, are the subject of similar controls to those under the Basel Convention.

The guidelines have been updated in 2001 (C(2001)107/Final) and are now roughly consistent with the Basel Convention.

7.3 Challenges and Loop-holes

7.3.1 Definitions

One of the major challenges facing those seeking to reduce the unwanted, often illegal, trade in e-waste is the near impossibility of clearly and consistently defining what types of equipment, shipped for what purpose and to what locations should be restricted. An added complication is the dual nature of e-waste as both a potential toxic threat and a valuable resource.

Policymakers have therefore sought to

focus on the intended purpose of the shipment: reuse, recovery or disposal. There has been a strong presumption that shipments for disposal should be heavily restricted. However it can be very complicated to ascertain from an objective point of view (i.e., those of an enforcement authority) what particular purpose a shipment is being made for. This has meant that as national authorities have begun to clamp down on shipments for disposal, companies are starting to ship items under the guise of being for reuse, when they were in fact destined to be disposed of in the destination country. Indeed, a telling statistic may reveal this practice. Between 1990 and 1995, the trade in waste for disposal shrank by 31 per cent whereas the trade in waste destined to be reused grew by 32 per cent. This now represents one of the greatest challenges to the regime put in place to stop the harmful trade in hazardous waste.

Another complication is the inconsistency between national policy and international agreements with regard to the definition of e-waste and most importantly, the definition of hazardous waste. As an example, the Basel Convention's definition and classification of e-waste is not harmonised with how they are defined by many signatory countries leading to inconsistencies and contradictions[123]. In addition, the lack of consistency on what is defined as hazardous is striking and again leads to an overly-complex regime[124].

The fast pace at which new EEE products are developed as well as the constant push to have electronics integrated into more and more types of products, together with their ever changing composition, means that it is almost impossible for classifications to keep pace with all the developments. This ensures that all classification lists are either incomplete or out of date.

7.3.2 Enforcement

In addition to the problems of definitions and classifications, there is the major problem that rules need to be enforced and monitored, which generally requires considerable resources and poses a number of challenges. The challenges are that at least some part of the trade is performed illegally making it invisible, unless a thorough inspection of the shipping container is performed. The sheer volume of product flowing through international ports makes even the monitoring and control of the legitimately labelled shipments very difficult. The monitoring of international shipments are further hampered by the lack of cooperation and information-sharing at all levels, from communication between national governments to communication between national, regional and local authorities and between different agencies involved in the monitoring like the police and customs officials.

The aforementioned complexity around the definitions of recyclable product, potentially hazardous waste and used goods "creates a grey area into which millions of tonnes of e-waste has disappeared"[125]. This grey area allows people to circumvent the enforcement regime by labelling the shipped good as suitable for reuse, and therefore used products, which ensures that all the policies mentioned above do not apply. The first major attempt to regulate this trade in second-hand goods was contained in Annex 6 of the recast EU WEEE Directive that mandated that it was the responsibility of the sender of the equipment to be able to prove that the equipment was destined for reuse. This reversed a long-standing duty on customs authorities to prove that products were not capable of being reused, which led to a very low rate of enforcement.

The testing of products is also a potentially problematic area, since even though some products like PCs or mobiles are easy to check for functionality, base stations and complex network equipment that only function as part of a larger system are much harder to test. This leads to a situation where it is very difficult for customs officials to make objective judgements about whether a particular shipment is hazardous waste or valuable second-hand products.

Having noted some of the major challenges facing enforcement officials, one could at least hope that once sure of an infringement, adequate punishment would be given to the offending party. However, the reality could not be further from the truth. On those rare occasions where the exporter is sanctioned, it generally only requires the payment of a small fine and taking back the illegal container of goods. It has been shown in studies that exporters often just try to ship the material again either in a different container from the same port or just try at another port[126].

Another factor complicating the enforcement of this vital area is the issue of ownership of the materials in transit. Shipping containers often change ownership many times on route to the final destination[127]. This often makes it very hard for customs officials to trace back the owner in order to enforce a return of the shipment. Many federal jurisdictions require the local authorities where ports are situated to become responsible for any materials for which an owner cannot be located. It has been argued that this creates an incentive to not question dubious shipments[128].

7.4 Policy options

Policy options in this area must be applied very carefully to ensure even a limited positive result. What has been evident by many policy instruments is that they sometimes produce unintended consequences and only tackle local symptoms rather than the global problem. In developed countries, policies that try to improve the treatment of e-waste by improving environmental regulation can lead to an export of the waste problem to the developing world. Similarly in developing countries, attempts to ban the import of e-waste and used equipment can stifle an industry that provides real employment to a large number of people and merely shift and environmental and human health problem, through improper treatment of e-waste, to a social problem of unemployment and lack of access to affordable used equipment.

There are therefore only limited options for effective unilateral policy decisions in this area, since effective harmonisation of definitions and standards are best achieved though multilateral conventions. It is therefore encouraging to see that the technical guidelines on the definition and distinction of e-waste and used products are being discussed within the framework of the Basel Convention.

7.4.1 Enforcement

There are two sound policy decisions that can be made unilaterally with regard to ensuring better and more effective enforcement.
Firstly, more resources should be provided to customs and harbour officials to help them in combatting the illegal trade in e-waste. Given all the other priorities that are often rightly deemed more critical for authorities to focus on, such as the arms trade, drug shipments, human trafficking it is little wonder that e-waste is not top of their priority list. Experience in the UK has shown that the most effective way to catch those exporting illegally is to focus on intelligence-led detective work. This also makes it easier to secure real convictions for offenses since a pattern of behaviour can be established and numerous infringements taken into account.
Secondly, penalties for trying to export e-waste illegally should be increased so that they provide some sort of meaningful deterrent, or at least a substantial inconvenience, to those trying to break the law. A very encouraging recent example from Nigeria sent a strong signal to those trying to import e-waste into the country when it detained the ship MV Marivia for attempting to import two containers of e-waste from the UK. The ship was only allowed to leave port once a bond of $500,000 was paid, in addition to the cost incurred by the detention of the ship[129].
Without proper investment in enforcement and increased penalties, no policy options have a real chance at success. It is therefore vital that this be part of any implementation package. At the same time, it should also be recognized that it is very unlikely that all illegal waste shipments can be stopped. As such, it is important that the developing countries build a recycling solution so improper treatment is prevented.

Case Study 16 Japan and increased enforcement measures against transboundary movements of waste

In order to combat the illegal export of e-waste out of Japan, the nation has implemented a number of additional policies to try to improve enforcement and empower customs officials with additional powers to require more detailed information about the shipments concerned. The Japanese system developed four core policies:

- All exporters need to submit photographs of the contents of the containers in addition to all the other official documentation required.
- This enables customs officials to quickly recognise if further investigation is required if the photos either look like e-waste or if the pictures provided do not match up with the reality of an inspection.
- Customs officials were given additional resources and equipment to randomly monitor shipments via x-ray and open inspections.
- HS codes have been mandated to apply to the four categories of e-waste that are covered by the Home Recycling Law to allow better monitoring of flows of imports and exports. This will allow for better intelligence in the future.

7.4.2 Mandate safe packaging as condition for shipping as used goods

As has been noted throughout this section, a major issue for enforcement officials is that they have little or no means to ascertain whether a shipment is e-waste or useful used products due to complex nature of the technical tests that would need to be carried out.

One easy way to infer whether the intention of the exporter is to ship products destined for reuse or if the shipment is just scrap destined for recycling and disposal is the way in which the products are packaged for shipment. It is widely accepted that when exporters ship products with the intention of repairing or reusing them, they always want to ensure that the products sustain as little damage as possible in transit. The economics of reuse are such that any damage in transit may render the product uneconomic to refurbish or reuse.

In the same way, it is very unlikely that any exporter who is shipping e-waste for recycling and disposal will take the time and effort to properly package the products. There are a number of reasons why this is very unlikely, which are again related to the economics of the activity taking place. Firstly, in order to package a product, the exporter need to purchase or acquire the packaging material which take times and resources. Secondly the exporter needs to pay someone to place all the items in the packaging. Then thirdly the exporter needs to accept that they will fit less tonnage of product per shipping container. All three of these reasons leads to the activity becoming much less profitable and possibly even unprofitable.

Providing enforcement officials with an objective way of accurately inferring the intent of the exporter also gives enforcement officials a simple way of controlling shipments that does not depend so much on subjective judgements of whether a product is e-waste or a valuable resource. The Correspondents' Guidelines to the Waste Shipment Regulations in the EU go part of the way to making the requirement when they state that "insufficient packaging for protecting items from damage during transportation, loading and unloading operations is an indication that an item may be waste". However, this does not really provide the enforcement officials with a smoking gun, but merely a reason for further investigation, which is potential obstacle to effective enforcement.

This criterion could become the key objective standard by which a shipment of used equipment can be differentiated from a shipment of e-waste. All shipments improperly packaged should be considered e-waste and the trade regulated and restricted.

7.4.3 National Import Regulations and Restrictions

Some countries, especially developing ones, have started to implement unilateral regulations and restrictions around certain types of products in certain circumstances. The table below taken from "E-waste Management – from Waste to Resources"[130] shows the current situation in Southeast Asia.

Table 16 2013 Overview of regulatory framework with regard to imports of e-waste and second-hand goods (SHEEE)

	SHEEE	*E-waste (WEEE)*
Cambodia	Possible (only PCs are prohibited)	Some items are prohibited as hazardous waste
China	Substantially prohibited (China Compulsory Certification is needed for home and large electrical machines. TV is prohibited.)	Prohibited except for waste motors, cables and others with restricted permission
Hong Kong	Possible (permission needed) Requirements: demand in Hong Kong, functioning products, proper packaging, and ≤5 years old	Possible (permission needed) Prohibited from Organization for Economic Cooperation and Development (OECD) and European Union countries and Liechtenstein
Indonesia	Many SHEEEs are prohibited	Prohibited if regarded hazardous waste
Japan	Possible	Possible (permission needed)
Macao	Unclear	Unclear
Malaysia	Possible (application needed) Requirements: functioning products, no physical damage, proper package, and ≤3 years old	Possible (permission needed) Prohibited from OECD countries
Philippines	Possible (permission needed)	Possible (permission needed)
Singapore	Possible (permission needed)	Possible (permission needed)
South Korea	Possible (safety certification needed)	Possible
Taiwan	Possible	Prohibited
Thailand	Possible Requirements: ≤3 years old (5 years for copiers), meets industrial standards, and product guarantee	Possible (permission needed)
Vietnam	Prohibited (laptop PCs allowed)	Prohibited

Prohibiting E-waste Exports and Imports

Some countries have decided to go further than the Basel Convention, which merely introduces a notification process for the shipments of hazardous waste, and prohibits the import of any in accordance is with Basel Ban Amendment adopted in 1995[131]. This is an important tool to help minimise the harm related to the improper treatment of e-waste, but this kind of policy option will only deliver results if there is the necessary level of enforcement with substantial penalties for infringement as well as a concerted effort to monitor and enforce the rules regarding the import of used equipment, since those wishing to circumvent any restrictions will almost certainly use this loophole amongst others.

It is vital that exporter countries, usually developed ones, play their part in helping to restrict the harmful export of e-waste and discourage the export of e-waste for disposal and recycling. Exporter countries are better able to deal with the enforcement issues, since the containers are, in many cases, in their country of origin. Developed countries are also in a better place to supply the required financial resources for enforcement to be effective, as well as judicial systems to handle the offenders. There is also a strong argument that exporter countries have a moral and ethical responsibility to ensure that they do not export potentially harmful material that cannot be properly treated in the destination country.

Case Study 17 China's prohibition of e-waste imports

China currently prohibits any import of unusable e-waste with only a few exceptions to that policy. With regard to used equipment there is a regulated regime for all imports, apart from TVs, which are prohibited. The regime requires that all imported used equipment should be tested by customs officials to ensure that the imported goods are comparable in quality and usability to new equipment[132].

Although these seem, and are, very sensible policies, they will only lead to real reduction in the import of e-waste to places like Guiyu if there is a commensurate focus on enforcement, which so far has not been evident. Additionally, it makes little sense to place onerous obligations on customs officials, like requiring them to check each product to assess its quality and suitability for reuse, since this will take such a vast amount of human time and resources and will be met with some of the challenges mentioned above around how to assess product functionality and the fast development of products.

In addition, making the trade illegal has introduced a significant criminal element to the equation making it harder to evaluate and tackle the remaining problem of informal recycling.[133]

The debate around the prohibition of e-waste has recently focused on exactly how wide the definition of e-waste should be. Historically, as noted above, there has been confusion around whether shipments for repair were e-waste or not. There is now a significant movement that seeks to ensure that all untested equipment be classified as e-waste, irrespective of the actual state of the product, intention of the sender or whether it is packaged properly. These actors seek to prohibit all equipment that is not tested as being fully functional from being shipped transboundary. The proponents of this view are of the opinion that the harm done in allowing such equipment to arise as waste within an environment that is not capable of handling the hazardous fractions far outweighs any potential benefits [134]. Opponents of the view argue that the approach may lead to an overall reduction in global reuse levels and increased new manufacturing as centralised global repair operations become impossible to operate[135].

Regulating imports based on product type and age

Rather placing nearly blanket bans, another policy option is to try and define what kind of e-waste and used products are still desirable to import and to then restrict everything that is outside of this definition. There are generally four categories that can be used to create such a distinction. They are generally product type, chemical composition of the product, age from date of manufacture and recycling capacity.

Once again, from a theoretical perspective, this kind of detailed distinction can make a lot of sense. In practice however, it is important to bear in mind that this kind of distinction can be playing into the hands of those wishing to work against the system. This can create another level of definitions and distinctions that are not in line with the global norm, which can create grey area and loopholes to be exploited. In addition, given the potential complexity, it also makes the job of enforcement more complicated. For instance, how is a customs official supposed to be able to judge between a three and five year old DVD player, or decide whether the level of a particular hazardous substance is above or below a certain threshold? These kinds of policies can only work if the enforcement authorities are given considerable additional tools and resources to combat the trade that they are trying to prevent.

Case Study 18 Thailand's permits to import e-waste

The government of Thailand regulates, but does not prohibit the import of both e-waste and used products, which is administered through a permit process. The provision of permits is based on three of the four criteria outlined above: chemical composition, age from date of manufacture and recycling capacity. In practice, this means that cooling equipment cannot be imported due to the CFC content. For a product to be imported for the purpose of reuse, it should be less than three years old and if destined for recycling the authorities should not allow in more products than the intended recycling facility can accommodate.

7.4.4 A green reuse channel

A final policy option that should be considered is the creation of certified channels along which used products destined for repair could travel freely. A major issue with increasing controls for every shipment, especially when covering used equipment, is that it will very likely lead to a reduction in the overall level of reuse, create more e-waste sooner and ultimately lead to an increase in the reliance on new product build. The reason for this is that any increase in the cost of moving used equipment for repair, as well as increased administrative burden, may lead OEMs to reduce their reliance on repaired and refurbished equipment.

It would therefore be potentially beneficial to have certain product flows certified and audited to allow for the particular OEM or other actor to use the certification to ensure shipments without delay and without additional cost, other than the cost associated the audit and certification.

An example of how this may work would be that OEM A has its EU returns warehouse located in Amsterdam, Netherlands. Here, the products are assessed and a decision is made as to whether these products can be reused or recycled. The products destined for recycling are recycled locally. Those destined for repair and refurbishment then need to be sent to the relevant repair location around the world. Lets us say that OEM A has three repair location, one in Hungary, one in the United States and one in China. Under this proposal, the OEM would submit a plan to all four country governments outlining the full processes that are followed at the facilities, what logistics providers are used and what will be done with any products that are found to be beyond repair in the destination countries. Then once approved, OEM A would be able to ship products to the three facilities mentioned in the approved plan using the logistics provider mentioned in the plan without further involvement or paperwork, subject, of course, to random checks to ensure compliance with the system.

8 Conclusion

This Green Paper gives the reader the opportunity to understand the wide variety of policy options that have been tried and implemented around the world as well as draw some conclusions about the nature of responses to the e-waste problem and potential policy recommendations.

FE-waste policies have evolved at a time when volumes of toxic waste were already very considerable as a result of the increase in consumption and disposal of EEE. Private initiatives, formal and informal, had also already started to organize e-waste transfer to developing countries. Scenes of children burning computer cables or refrigerators and keyboards floating in the dark waters of a river polluted by heavy metals and chemical cocktails should belong in the past. Unfortunately, they are still representative of the reality in too many areas of the world.

In the 2000s, policymakers in industrialized and emerging countries have focussed a lot of their efforts on developing financing and awareness schemes focused on ensuring better participation of both the private sector and individuals in ensuring higher collection rates and that the finances are in place to meet the treatment costs.

While the promotion and capacity-building of effective and efficient take-back solutions for EoL material is vital, this paper notes that there should also be a concerted effort to focus more energy on the reduction of e-waste volumes and the repair/reuse of EEE. Although a number of initiatives have been identified, especially by not-for-profits and the informal sector, there are few examples of public policy initiatives that have been successful. Importantly, the focus on repair and reuse enables the extension of product lifecycles, postponing their disposal and reducing the relative environmental footprint generated through production.

There is also a lack of adequate incentives for producers to focus on eco-design options that would enable them to put less toxic, easily repairable and recyclable products on the market. In addition, there is a lack of publically available data that would allow producers and third parties to evaluate potential substitutes to hazardous metals and chemicals that are currently indispensable to many products.

The authors of this Green Paper therefore suggest that StEP encourages further research on the effective means of reducing overall e-waste volumes arising worldwide, ways of encouraging repair and reuse both by producers and consumers and as promoting eco-design.

In terms of **policy recommendations**, this Green Paper has sought to present a variety of policy options, most of them being already implemented, on a large scale or in pilot in both (post-) industrialized and developing countries. A minority of recommendations are suggestions gathered from scientific work, the private sector or civil society organizations. The authors have tried to identify the pros and cons of each policy option, since there is no one-size-fits-all solution for e-waste policy; what works under some conditions may be wholly inappropriate in others.

Concerning the scope of an e-waste management system, the conclusion is that ideally, it is recommended the scope should be exhaustive, but that in practice, this could prove to be too ambitious, especially for countries that are just starting to implement e-waste policies. Where this is the case, a phased scope could be implemented with a clear and detailed ambition to cover all products in a reasonable timeframe. It is also vital to consider whether to include B2B products and clearly identify where they are excluded or require different compliance procedures.

The overall system structure and respective roles within it are vital to articulate and define. Special attention should be given to clarifying and detailing the roles of public authorities, producers, recyclers and other individuals. The implementation of the principle of EPR, which, as outlined, poses some specific challenges for developing countries, should be considered as a method of apportioning responsibility.

The involvement of the informal sector, especially, but not exclusively, in the developing world must be considered when developing e-waste policies as they are key actors in the chain often performing important work under harsh conditions. Although there is no ideal process for doing this, three important steps have been identified in this paper:

- Firstly, there should be an effort to identify and understand the sector.
- Secondly, there should be efforts to include, upskill and promote where their involvement is desirable and the harm done to individuals and the environment can be mitigated. StEP's "Best of 2 Worlds" approach seems to

have identified a modus operandi by operating synergies between the informal sector and the industry that best achieves this goal.
- Finally, where appropriate, efforts should be made to formalise the sector.

As mentioned above, there are a lack of effective policy options to improve prevention and reuse of e-waste. However, it is clear that efforts should be made to encourage producers to design products using fewer toxic materials with longer life-time. Equally, the notion of responsible consumption needs to be encouraged by promoting the purchase of repaired and refurbished products. Consumers also need to be aware that a $20 DVD player is unlikely to last very long beyond the warranty time, nor ever be economical to repair. The old adage of "you get what you pay for" remains true.

For the separation at source and collection of e-waste, models have to be adapted to the local context and available means as well as understanding and any existing infrastructure from the formal or informal sector. However, some things are vital for a functioning system. Firstly, it is necessary to have an effective means of collecting e-waste. This can be provided by a variety of parties in various combinations from informal operators, government, retailers, commercial shops and producers.

- From a policy perspective it is advisable that realistic targets are set and that progress against these measures is recorded.
- Where appropriate, it can be positive to encourage local authorities to provide collection points. Similarly, obligations on sellers of products to also provide collection points has proved effective under some conditions.

Recommendations on appropriate recycling and disposal rely on complying to existing international norms and standards. The challenge is to make sure that these standards are known, understood and applied even in the least industrialized countries. The complexity of safely treating some components of e-waste and the investment required to build the necessary facilities suggests that their safe recycling and disposal may mean that it is not financially viable nor desirable to have all e-waste treated locally. This is another reason for embracing the "Best of 2 Worlds" approach.

On the financing scheme, the authors conclude that although there is no perfect model, some conclusions can be drawn. The EoL fee seems, to the authors, to be the least effective, and since it relies on the consumer paying at the time of discarding, offers the strongest disincentive to properly discard a product. Up-front fees have the distinct advantage of being very simple to implement, administer and control but also suffer from being inflexible and are notorious for building up huge financial reserves at the expense of the consumer. Market share models, which from a theoretical perspective may be the best, since they only charge producers for actual costs rather than estimated costs, suffer because they can be more complex to administer than other models. Ultimately, any policymaker will have to judge which system best meets their needs and capabilities of the stakeholders.

Last but not least, controlling transboundary flows of e-waste remains a big challenge, and the implementation and enforcement of existing international conventions remains inadequate. The area is further complicated by the lack of clear and consistent legal definitions around e-waste and reusable products. This lack of clarity further compounds the difficulty of enforcing the rules along with a lack of sufficiently deterrent penalties. The first priority for all public authorities wishing to tackle the problem is to provide clear guidance to enforcement officials as well as providing them with the necessary resources to be effective. In tandem, penalties for infringement should be increased, so that they offer a meaningful deterrent. Secondly, adequate and safe packaging should be mandated as a requirement in order for the products contained within the shipment to be considered reusable rather than e-waste.

Once these measures are implemented, it may then be appropriate for those countries with specific problems to implement selective bans by type and/or age of product. In extreme cases, a total ban on the import of e-waste may be appropriate. Finally, policymakers should consider the feasibility of creating green reuse channels to ensure that product reuse is not impeded.

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- The Sustainability Consortium
- UMICORE Precious Metal Refining
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- United Nations Industrial Development Organization (UNIDO)
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About the Step Initiative:

"Step envisions to be agents and stewards of change, uniquely leading global thinking, knowledge, awareness and innovation in the management and development of environmentally, economically and ethically-sound e-waste resource recovery, re-use and prevention."

Step is an international initiative comprised of manufacturers, recyclers, academics, governments and other organizations committed to solving the world's waste electrical and electronic - e-waste - problem. By providing a forum for discussion among stakeholders, Step is actively sharing information, seeking answers and implementing solutions.

Our prime objectives are:

- Research and Piloting
    - By conducting and sharing scientific research, Step is helping to shape effective policy-making
- Strategy and goad setting
    - A key strategic goal is to empower pro-activity in the marketplace through expanded membership and to secure a robust funding base to support activity
- Training and Development
    - Step's global overview of e-waste issues makes it the obvious provider of training on e-waste issues
- Communication and branding
    - One of Step's priorities is to ensure that members, prospective members and legislators are all made aware of the nature and scale of the problem, its development opportunities and how Step is contributing to solving the e-waste problem.

The Step initiative came about when several UN organizations, who were increasingly aware of the growing global e-waste problem, saw the need for a neutral, international body to seek real, practical answers that would be supported by manufacturers, recyclers and legislators alike.

Step's core principles:

1. Step views the e-waste issue holistically, focusing on its social, environmental and economic impact – locally, regionally, globally.
2. Step follows the lifecycle of equipment and its component materials from sourcing natural resources, through distribution and usage, to disposal.
3. Step's research and pilot projects are "steps to e-waste solutions".
4. Step vigorously condemns the illegal activities that exacerbate e-waste issues, such as the illegal shipments, recycling practices and disposal methods that are hazardous to people and the environment.
5. Step encourages and supports best-practice reuse and recycling worldwide.

Contact:
Step Initiative
c/o United Nations University
Institute for the Advanced Study of Sustainability (UNU-IAS)
Operating Unit SCYCLE
Platz der Vereinten Nationen 1
53113 Bonn, Germany
Phone: +49-228-815-0271
Fax: +49-228-815-0299
info@step-initiative.org
www.step-initiative.org
www.ias.unu.edu

UNITED NATIONS UNIVERSITY