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Recommendations on Standards for Collection, Storage, Transport and Treatment of E-waste

Principles, Requirements and Conformity Assessment

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Principles, Requirements and Conformity Assessment

by

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Acronyms

CA	Conformity assessment
CCFL	Cold cathode fluorescent lamps
CFC	Chlorofluorocarbons
DfE	Design for environment
DfEoL	Design for end of life
DfR	Design for recycling
EEE	Electrical and electronic equipment
EHS	Environment, health and safety
EHSM(S)	Environmental, health and safety management (system)
EoL	End of life
EU	European Union
FPD	Flat panel display, flat screen
HCFC	Hydro chlorofluorocarbons
HFC	Hydro fluorocarbons
NGO	Non-governmental organization
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PWB	Printed wiring board, also printed circuit board
SoC	Statement of conformity

Definitions

Accreditation	Third-party demonstration that specified requirements relating to a product, process, system, person or body are fulfilled related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks (ISO 17000)
Audit	Systematic, documented process for obtaining records, statements of fact or other relevant information and assessing them objectively to determine the extent to which requirements of a standard are fulfilled (ISO 17000)
Best Available Technology	The latest stage of development (state-of-the-art) of processes, facilities or methods of operation indicating the practical suitability of a particular measure for the collection, transport, storage and treatment of e-waste[1]
Certification	Issue of a third-party statement that fulfilment of the requirements of a standard has been demonstrated related to products, processes, systems or persons (ISO 17000)
Certification system	Organization of a third party conformity assessment system
*C*hlorofluorocarbons (CFC)	Class of cooling agents used in older cooling and freezing equipment with high global warming and ozone depletion potentials[2]; also used for foaming of plastics like polyurethane
Cold cathode fluorescent lamp	Lamps used as backlights in flat panel displays; contain mercury
Confirmation	Issue of a second-party statement that fulfilment of the requirements and targets of a standard has been demonstrated related to products, processes, systems or persons
Conformity assessment	Demonstration that the requirements of a standard relating to a product, process, system, person or body are fulfilled (ISO 17000)

[1] Organization for Economic Co-operation and Development (OECD), Glossary of Statistical Terms. Available from http://stats.oecd.org/glossary/detail.asp?ID=6358 (accessed 1 April 2012).
[2] United States Environmental Protection Agency (EPA), Ozone Depletion Glossary. Available from http://www.epa.gov/ozone/defns.html (accessed 27 February 2012).

Conformity assessment body	Body that performs conformity assessment services (ISO 17000)
Conformity assessment system	Rules, procedures and management for carrying out conformity assessment (ISO 17000)
Declaration of conformity	Issue of a first party statement that fulfilment of the requirements and targets of a standard has been demonstrated related to products, processes, systems or persons (ISO 17000)
Disposal	Any operation, which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy (WEEE Directive 2012, Waste Directive 2008)
Electrical and electronic equipment	Equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields (WEEE Directive 2003)
E-waste	Any EEE, which the holder discards or intends or is required to discard, including all components, subassemblies and consumables which are part of the product at the time of discarding (WEEE Directive 2012, Waste Directive 2008)
Effectiveness	Measure for the extent to which the stated objectives of a process or procedure have been met[3]
Eco-efficiency	Measure indicating the environmental benefit of an economic investment; or, conversely, the investment necessary to achieve a stated environmental benefit
Efficiency	Measure for the economical, ecological or other kind of expenses necessary to achieve a stated objective
End of life (EoL)	Final stage in the life cycle of a product, beginning at the point in time when the product becomes waste and continuing until its final disposal, or until the waste, components, fractions or materials thereof meet the end-of-waste criteria
End-of-waste criteria	Waste shall cease to be waste when it has undergone a recovery operation including preparation for re-use and complies with specific criteria, in particular: there is an existing market or demand

[3] Organization for Economic Co-operation and Development, Glossary of Statistical Terms. Available from http://stats.oecd.org/glossary/detail.asp?ID=4775 (accessed 1 March 2012).

	for the material, the use is lawful, the use will not lead to overall environmental or human health impacts [4]
EoL operation	Collection, handling, storage, transport, treatment and disposal of e-waste, components, fractions or materials thereof
EoL operator	Any entity conducting EOL operations or management of e-waste, such as collectors, transporters, recyclers, smelters, and takeback systems
EoL standard	Standard for the collection, storage, transport and treatment of e-waste
First party	Person or organization that provides an object or service (ISO 17000)
First-party conformity assessment	Conformity assessment that is performed by the person or organization that provides the object or service (ISO 17000)
Handling of e-waste	All operations not intending to manipulate the composition and condition of the e-waste
Hydrochlorofluorocarbons (HCFC)	Cooling agents with high global warming and ozone depletion potentials used in older cooling and freezing equipment[5]
Hydrofluorocarbons (HFC)	Cooling agents with high global warming potentials used in older cooling and freezing equipments[5]
Media sanitization	Actions taken to render data written on media unrecoverable (NIST 2006)

[4] European Commission, End of Waste Criteria. Available from http://ec.europa.eu/environment/waste/framework/end_of_waste.htm (accessed 27 February 2012).
[5] United States Environmental Protection Agency (EPA), Ozone Depletion Glossary. Available from http://www.epa.gov/ozone/defns.html (accessed 27 February 2012).

Non-governmental organization (NGO)	An organization that is independent from government; environmental organizations and industry associations are among the many types of NGOs
Polybrominated biphenyls	A flame retardant used in electrical and electronic equipment; since 2006 banned by the European (RoHS Directive 2003) in all EEE put on the EU market
Polybrominated diphenyl ethers	A flame retardant used in electrical and electronic equipment; since 2006 banned by the European (RoHS Directive 2003) for EEE put on the EU market
Preparation for re-use	Recovery operations, such identifying, checking, cleaning or repairing, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing (WEEE Directive 2012, Waste Directive 2008)
Recovery	Any operation the principal result of which is waste serving a useful purpose by replacing other materials that would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy (WEEE Directive 2012, Waste Directive 2008)
Recycling	Any recovery operation by which waste materials are reprocessed into products or materials whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations (WEEE Directive 2012, Waste Directive 2008, modified)
Removal	Manual,mechanical, chemical or metallurgic handling with the result that hazardous materials and components are contained in an identifiable stream or are an identifiable part of a stream within the treatment process. A material or component is identifiable if it can be monitored to prove environmentally safe treatment (WEEE Directive 2012, modified)
Re-use	Re-use of electrical and electronic equipment or its components is to continue the use of it (for the same purpose for which it was conceived) beyond

	the point at which its specifications fail to meet the requirements of the current owner and the owner has ceased use of the product (StEP Initiative).
Second party	Person or organization that has a user interest in an object or service (ISO 17000)
Second-party conformity assessment	Conformity assessment that is performed by a person or organization that has a user interest in the object or service (ISO 17000)
Standard	Formalized set of harmonized, consistent and acknowledged or established requirements applied to manufacturing processes, products, services and procedures (ISO 17000)
Statement of Conformity (SoC)	Conveys the assurance that the requirements of a standard have been fulfilled (ISO 17000)
Third party	A person or body that is independent of the person or organization that provides an object or service and of user interests in that object or service (ISO 17000)
Third party conformity assessment	Conformity assessment that is performed by a person or body that is independent of the person or organization that provides the object or service and of user interests in that object or service (ISO 17000)
Treatment	Recovery or disposal operations, including preparation prior to recovery or disposal (WEEE Directive 2012, Waste Directive 2008)

1 Introduction

1.1 Objectives of this paper

Sales of electrical and electronic equipment (EEE) globally have been rising rapidly in the last decades. The generation of electrical and electronic waste (e-waste) has risen accordingly. Currently, the world generates around 40 million tonnes of e-waste every year. E-waste is among the fastest growing waste streams with the highest growth in developed as well as in developing countries and in countries with economies in transition. (UNEP 2009)

E-waste contains numerous materials, toxic metals and organic materials as well as valuable and scarce resources (Buchert 2009). In order to prevent pollution, and to save valuable resources, e-waste requires specific treatment. As compared to other waste streams, e-waste is highly complex, it must be collected separately and treated carefully to enable environment-friendly and safe treatment.

In practice, however, low collection rates, improper collection, inadequate transport, storage and treatment, incineration and landfilling of e-waste, as well as illegal exports are common. Even in the European Union (EU), despite comprehensive e-waste legislation, only around one-third[6] of e-waste is reported as being treated according to the state-of-the-art. In other regions of the developed world, legislation is missing or patchy, or limited to only a few categories of e-waste. This results in the disposal and incineration of e-waste or in inadequate treatment and export of e-waste to developing countries. Finally, in developing countries and in countries with market economies in transition, effective e-waste legislation may not be available or may not be enforced. The deficiencies in end of life (EoL) operators' awareness, monitoring of EoL operators, and knowhow, results not only in the loss of valuable resources, but in severe environmental pollution and health problems, particularly in developing countries. (BAN 2002, Basel Convention 2011, PACE 2009, Sepulveda 2010).

The root causes of these e-waste challenges are manifold. They include technological, infrastructural, institutional, legislative and political deficits, as well as a lack of knowhow and awareness among producers, consumers and EoL operators. Given the complexity of e-waste management and the multitude of actors involved, there are no simple solutions. A combination of approaches and steps are needed to address the various root causes of e-waste management challenges.[7]

High quality EoL standards can be one contribution to protect the environment and the health and safety of people from the severe consequences of improper EoL management of EEE, as well as to save valuable resources in EEE. EoL standards can, in particular, contribute to an increase in the individual environmental performance of each operator in the EoL chain. Furthermore, by better aligning and regulating EoL operators' activities, EoL standards can improve the environmental performance of the entire EoL chain. EoL standards aim to make EoL operators' per-

[6] Commission of the European Union, "Questions and answers on the revised directive on waste electrical and electronic equipment (WEEE)", 3 December 2008; available from http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/764 (accessed 28 February 2012)

[7] StEP Initiative, Task Forces. Available from http://www.step-initiative.org/taskforces/tf1.php (accessed 19 February 2012)

formance transparent, thus creating a level playing field for all operators and enabling fair competition in terms of both price and quality of EoL services. Due to the differences among developed countries, and between developed and developing countries, however, it is unlikely that a single standard will be practical or effective. Specifically-tailored standards must be developed for each country or region.

The goal of this paper is to be a guide for the setup of country- or region-specific EoL standards taking into account best practices and best available technologies (BAT). This paper is not an EoL standard. Rather, it gives an overview of the principles for the setup of EoL standards, suggests requirements standards for EoL of EEE should address and proposes approaches for translating the requirements into stipulations of an EoL standard.

Because standards, alone, will have little effect if EoL operators' compliance is not reliably audited, this paper also addresses principles and practices of sound auditing and certification. Finally, as several EoL standards have been set up and are about to be implemented recently, care must be taken to ensure that EoL operators do not have to work under multiple standards, which would increase both administrative burdens and operational costs. This paper proposes strategies for the application and harmonization of EoL standards, and for increasing their overall quality and effectiveness over time.

1.2 Definition and Types of Standards

ISO 17000 defines standards as a formalized set of harmonized, consistent and acknowledged or established requirements applied to manufacturing processes, products, services and procedures. Standards can be differentiated into two main groups: (i) technical standards and (ii) management standards. Technical standards specify technical properties of products or product parts, or of manufacturing processes. Examples for such specifications are the USB connectors used in computers.[8]

Management standards relate to the organization and maintenance of certain procedures in order to achieve a specific objective such as reducing the environmental impact of a product or company, or to ensure traceability and quality of manufacturing or services. Examples are environmental, health and safety management standards (EHSM) like the (ISO 14000) and the ISO 9000[9] series, EMAS[10] or OHSAS[11].

Standards for collection, transport, storage and treatment of e-waste (EoL standards) can be classified as management standards as well as technical standards, because

[8] Universal Serial Bus, USB 3.0 Specification. Available from http://www.usb.org/developers/docs/ (accessed 19 February 2012)

[9] International Organization for Standardization, ISO 9000 essentials, http://www.iso.org/iso/iso_9000_essentials (accessed 20 February 2012)

[10] European Commission, EMAS, What is environmental management?" Available from http://ec.europa.eu/environment/emas/about/enviro_en.htm (accessed 19 February 2012)

[11] OHSAS, OHSAS Electronic Toolkit. Available from http://www.ohsas-18001-occupational-health-and-safety.com/ohsas-18001-kit.htm (accessed 19 February 2012)

they may specify managerial as well as technical requirements.[12]

Standards, which are different from legislation, are typically set up and enacted by non-governmental organizations (NGOs), not by governments. Standards may be established by single manufacturers or service providers for internal use. For example, standards may be established to guide internal activities or as requirements for an organization's suppliers and service providers.

Over time, such internal standards may become acknowledged and established in a market by repeated and common use, or by agreement between several manufacturers or service providers. Given the potential for improved administrative and technical efficiencies, it would serve producers, service providers, and their associations well to cooperate to establish a shared standard in the market. Producers, service providers, or their associations may submit standards to national or international standardization bodies to make them national or international standards.

1.3 Standards and Legislation

Even though governments normally do not set up standards, they may give a mandate to national or international standardization bodies to develop standards for use in national or international markets. The European Commission may, for example, ask the European standardization organizations to develop standards.[13] Such standards are then published in the Official Journal of the European Union and thus become harmonized standards, which are acknowledged throughout the European Union and may be referenced in European legislation.

Standards are less binding than legislation. They are typically applied in business-to-business or in public-private contractual relationships. Governments, companies, or other bodies may require their suppliers and service providers to work according to a certain standard. In this case, the standard becomes legally binding as part of contractual provisions between these parties. The legal authority of standards is thus limited to the contractual relationship between contract partners and there is usually no legal obligation to stipulate compliance with a specific standard in a contract. The use of standards in this sense is voluntary, unlike the compliance with legal requirements. Nevertheless, standards can come to define the state-of-the-art if they find broader acceptance and are incorporated into many contracts in a sector of industry. Additionally, governments can declare a certain standard as “state-of-the-art” in laws or ordinances. Voluntary standards can thus deploy normative power and influence practice on a large scale.

Standards are an important complement to legislation. In the absence of legislation, they may even pioneer the regulation of certain fields or activities at an operational level. Standards may adopt or derive requirements and targets from legislation, operationalize them (see section 3.1 on page 25) and thus facilitate better monitoring of legal compliance. Standards may al-

[12] As an example, see Annex C (Batch Testing) of the WEEELABEX treatment standard; available from http://www.weee-forum.org/system/files/weeelabex_v9.0_standard_on_treatment.pdf; (accessed 8 May 2012)

[13] Seconded European Standardization Expert for China (SESEC), European Standards. available from http://www.eustandards.cn/european-standardization/european-standards-2/ (accessed 19 February 2012)

so complement legislation. Beyond legislation, standards may also define requirements and targets without a base in legislation, as long as they do not violate or infringe upon legal requirements.

Nevertheless, the creation and enforcement of sound legislation remain important roles of governments and public authorities. Standards have limited legal authority. Because, in most cases, they are voluntarily-applied instruments, their efficacy will be greatly improved if operating on top of a robust legislative baseline.

2 Principles for the Setup of EoL Standards

2.1 Target Orientation

EoL standards shall set clear requirements for EoL operators. However, standards should abstain from prescribing the means, such as particular technologies or practices to achieve the stipulated requirements. With time and room to operate, EoL operators will find new, more effective, and more efficient ways to achieve the requirements. Ambitious EoL standards with strict target orientation will stimulate innovation for continuous improvements towards increasing EoL operators' environmental and economic performance. The target orientation principle does not stipulate the use of best available technologies (BAT) or certain best practices. However, because BAT and best practices demonstrate ideal outcomes, they can give orientation for setting requirements.[14]

2.2 Clear Scope and Stakeholder Responsibilities

There is considerable debate over the precise definition of "e-waste," as well as the types of materials that comprise it. E-waste is commonly understood to include only information and communication technology (ICT). While ICT is an important part of EEE, it comprises only a portion of the total amount of e-waste produced each year. The term "e-waste" must be interpreted more broadly to include other categories of EEE, such as cooling and freezing equipment and electrical and electronic tools, as the specifics of managing this type of waste necessarily sets it apart from other types of waste. Annex I of the European (WEEE Directive 2003), for example, indicates ten categories of EEE that fall under the term e-waste at their end of life.

Standards for collection, storage, transport and treatment of e-waste are necessary for all types of EEE, which require separate collection and treatment to facilitate effective and efficient pollution prevention and resource saving. Furthermore, because e-waste comes from many different types of EEE, different types of e-waste require different collection and treatment. Each standard should therefore clearly specify the type of e-waste it applies to and clearly stipulate the requirements for this type of e-waste.

The EoL chain, from the consumer to material recycling and eventually to final disposal, involves many different stakeholders. Standards should define the responsibilities and roles of each stakeholder involved in the EoL of specific types of e-waste. If these responsibilities remain unclear, EoL operators may not know what

[14] European Commission Joint Research Centre, Institute for Prospective Technological Studies; available from http://eippcb.jrc.es/reference/ (accessed 26 February 2012)

they must do to comply and the EoL standard may not be effective.

2.3 Precautionary Principle

Many new types of EEE are introduced into the global market every year, with each type of EEE containing numerous chemical elements and compounds. Due to the rapidity with which new EEE are introduced, there may be insufficient scientific evidence and experience regarding their impacts on the environment, health and safety.

In cases of substantiated suspect that severe adverse environmental or health impacts may occur during the collection, storage, transport and treatment of specific types of e-waste, the precautionary principle shall apply. The requirements in an EoL standard should then be set assuming that the suspected adverse impacts may actually occur.

2.4 Auditability of Requirements

Standards shall create transparency concerning operators' technical and organizational capacities, their knowledge and their actual successes in meeting targets and requirements. All targets and requirements in a standard must be set in a way that they can be both assessed and controlled in conformity assessments.

A requirement like the following is too general to be monitored or audited and is therefore of little value in a standard:

- "Promote re-use over recycling."

A more specific and precisely worded requirement, such as the following, allows for the effective monitoring and auditing of operators:

- "Operators shall demonstrate that they have trained staff, procedures and infrastructure in place to identify, separate and store equipment, which is in a state that may allow for both its preparation for re-use and its subsequent re-use. Operators must prove that they have the expertise and infrastructure to test, upgrade, refurbish and package the equipment for re-use."

The above example contains clearly stated stipulations that can be effectively evaluated through audits of operators' facilities and interviews with, or surveys of, the facilities' workers.

Another important component of auditability is the documentation by operators of their practices and procedures in managing e-waste. This documentation will provide evidence of their daily performance and their compliance with standards. Documentation comprises licenses from authorities, mass balances, confirmations for hazardous materials sent to further treatment, and all other evidence of the operator's ability and daily efforts to comply with standards.

2.5 System Approach

2.5.1 Coverage of the Entire EoL Chain

Re-use and environmentally sound recycling of e-waste require the cooperation of all EoL operators and the optimization of the entire EoL chain. High quality recycling may already fail in the upstream operations if e-waste is damaged during collection, storage or transport, or if it is sold to brokers outside established and appropriate treatment schemes for e-waste. Illegal transboundary shipments or illegal dumping may occur at each stage of the EoL chain.

EoL standards are needed for all operators involved in the EoL chain of EEE, including operators involved in:

- Collection
- Transport
- Storage
- Preparation for re-use
- Treatment and disposal of non-recyclable parts, fractions, and materials

A set of standards composed of requirements clearly addressing the operators in each stage of every EoL phase is therefore recommended. Figure 1 shows an example of the architecture of such a set of standards.

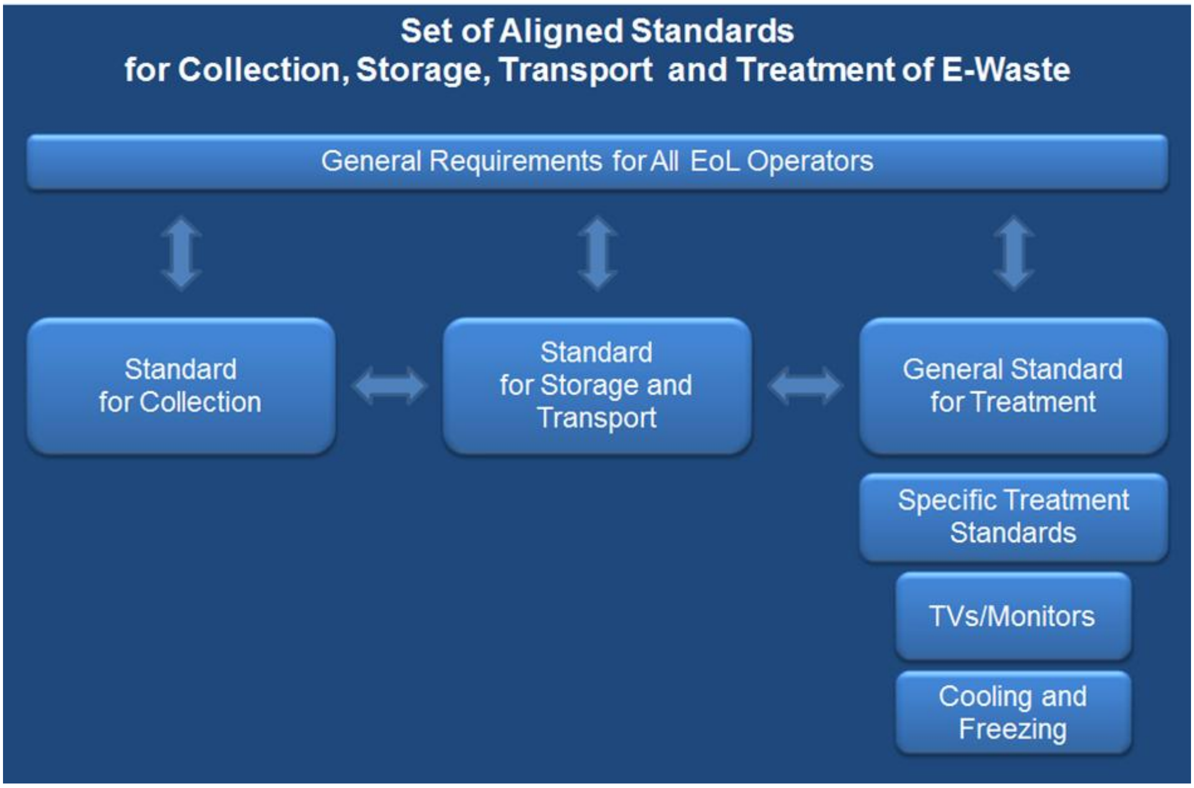

Figure 1: Example architecture of EoL standards covering the entire EoL chain of EEE

The coverage and alignment of all EoL operators' activities in multiple EoL stages within such a set of standards will help identify and achieve improvement potential, which would likely remain unfulfilled if operating under a single standard covering only a single EoL stage.

2.5.2 System Approach for Setting of Requirements

In setting requirements in EoL standards, two aspects must be taken into account:

- Each requirement should help improve the performance of the EoL operators in a specific stage of e-waste management, such as collection, transport or treatment.
- The requirement should also maximize, or at least maintain, the environmental and economic performance of other operators in the entire EoL chain.

In addition to the operational requirements for collection, transport and treatment of e-waste, the design of EEE also influences EoL performance. Design for EoL (DfEoL) can thus contribute to the improvement of EoL performance. Product design aspects should, however, be based on a life cycle-based approach. DfEoL is just one aspect of Design for Environment (DfE), the goal of which is to optimize the overall environmental performance of a produce. DfE measures based on EoL considerations alone, may increase the environmental burdens in other stages of a product's life cycle. The ban of lead in EEE in the (RoHS Directive 2003), for example, was enacted to avoid environmental impacts in the EoL phase of EEE, but has increased the overall energy consumption and the use of scarce resources in the manufacturing of EEE (Deubzer 2007). As EoL standards necessarily narrow the perspective to the EoL phase of EEE, product design requirements should be addressed in life cycle-oriented regulations, standards and guidelines such as the (ErP Directive 2009), not in EoL standards.

2.6 Effectiveness and Efficiency as Approach to Environmental Performance

EoL operators' environmental performance includes pollution prevention and resource conservation. This comprises direct measures - e.g. treatment of materials - and indirect measures - e.g. enabling and preparatory activities such as collection and transport of materials. The operators' environmental performance is a key part of EoL standards. In order to facilitate a better understanding and the development of a more systematic approach to environmental performance, it is useful to differentiate it into effectiveness and efficiency of EoL operations.

2.6.1 Effectiveness of EoL Operations

The effectiveness of EoL operations is determined by their successful prevention of pollution from e-waste and their ability to recover the environmental or economic value contained in e-waste The effectiveness of EoL operations' pollution prevention and recycling, respectively, can be expressed generically in the following two equations, wherein ε = effectiveness:

$$\varepsilon = \frac{\text{Environmental damage avoided}}{\text{Total environmental damage potential of e-waste}}$$

Equation 1: Effectiveness of pollution prevention

$$\varepsilon = \frac{\text{Environmental value of materials recycled from e-waste}}{\text{Total environmental value of materials contained in e-waste}}$$

Equation 2: Effectiveness of recycling operations

In EoL operations, the effectiveness should be as close as possible to $\varepsilon = 1$. Such highly effective pollution prevention and recycling require the cooperation of all EoL operators and the alignment and optimization of their activities, beginning with high collection rates of e-waste, proper storage and transportation of the collected e-waste to avoid damages, followed by effective treatment processes.

2.6.2 Efficiency

EoL operations generate environmental benefits such as pollution prevention and resource savings. However, such operations also produce negative environmental burdens such as energy and water consumption, waste, noise and other emissions into air, soil and water. The efficiency of EoL operations is a measure of the environmental benefits EoL operations can achieve at a given level of environmental impact. Equation 3 describes the efficiency (η) of EoL operations:

The objective for EoL operations is to maximize the environmental benefits while minimizing environmental impacts. The higher the value for η, the higher the efficiency of the EoL operations.

$$\eta = \frac{\text{Environmental benefits through EoL operations}}{\text{Environmental impacts caused by EoL operations}}$$

Equation 3: Efficiency of EoL Operations

Eco-efficiency $\eta(e)$ is a specific form of efficiency combining environmental benefits of EoL operations with the associated economic impacts:

$$\eta(e) = \frac{\text{Environmental benefits through EoL operations}}{\text{Economic benefit from EoL operations} - \text{Cost of EoL operations}}$$

Equation 4: Eco-Efficiency of EoL Operations

The equation to measure eco-efficiency in the EoL of e-waste is a tool to identify EoL options where a given economic investment yields the highest environmental benefit or how a given environmental benefit may be achieved at minimum cost (Huisman 2003, ISO 14045).

In practice, the requirements in EoL standards should balance effectiveness and efficiency of EoL operations in seeking to achieve high environmental performance at acceptable costs. This is an important precondition for applicable standards, which are acceptable to operators and other stakeholders involved in EoL operations.

2.7 Market over Bureaucracy

For EoL operators, complying with standards requires additional efforts and may increase administrative burdens, and in so doing, may lead to additional costs. EoL standards should therefore only set requirements in instances where the market currently and in the long term does not effectively drive EoL operators to achieve desired levels of environmental EoL performance.

For some types of equipment, such as mobile phones or computers, ecological and economic advantages from better recycling go hand in hand. There are, however, cases where the market nevertheless fails to drive high effectiveness and efficiency among EoL operators. This may have a number of reasons, including a lack of information in the market, unfavorable legal or other framework conditions, and improper use of techniques and technologies on the part of EoL operators (Chancerel 2010). If market mechanisms do not cause EoL operators to meet requirements, standards must be set to ensure an appropriate environmental EoL performance.

2.8 Periodical Review

EoL standards should be reviewed periodically in order to keep them up to date with the most recent scientific findings and technological progress. Requirements and targets in an EoL standard should be oriented at the performance of best available technology (BAT) and practices. Because science and technology progress rapidly, with new types of electrical and electronic products constantly entering the market, EoL standards must be reviewed periodically in order to adapt to the changing technological landscape. Periodic reviews are also important to keep up with changing legal, political and economic conditions. Finally, it is essential to review standards in order to learn from the experiences of putting them into practice.

EoL standards should therefore stipulate a review period and be sufficiently dynamic to allow for their adaptation to changing contexts. Most standards are the result of complicated processes involving many stakeholders. Without a stipulated review date, the update of standards may become subject to stakeholders' particular interests, thus delaying or even precluding the review of standards.

Review periods of four or five years may be appropriate as a compromise between keeping standards up to date and keeping the expenses for their review and implementation within reason.

3 General Requirements

3.1 Legal Compliance

All operators have to comply with local, regional, national and international legislation applicable to their type and size of operations. Legal compliance on the part of EoL operators is mandatory, regardless of whether or not a standard is in place. An EoL standard may add benefits beyond the legal requirements if it operationalizes legal compliance to make it auditable.

The proof of legal compliance in EoL standards covers two aspects:

- Knowledge of applicable legislation and proof of compliance
- Ability to track changes in current legislation, and to obtain information on new and upcoming legislation

3.1.1 Knowledge about Applicable Legislation and Proof of Compliance

Operators should be in a position to show that they are informed about the legislative requirements applying to the type and size of their activities in the country, region and city of their operation. Standards may require operators to have updated inventories of all applicable legislation and their legal obligations. They shall keep records comprising a list of all necessary legal permits, licenses and other documents and documentation from authorities or business partners, such as loading and shipping confirmations. Operators must document that they understand the legal requirements and apply them correctly in their daily operations.

3.1.2 Ability to Track Changes in Legislation

Operators shall demonstrate that they have installed management structures and initiated measures to ensure that they will stay up to date with legal developments and their legal obligations. This may comprise measures like newsletter subscriptions, membership in respective associations, regular participation in seminars, routine investigations in the internet and other measures.

To meet these requirements, operators must allocate clear responsibilities to trained and knowledgeable staff in order to continuously monitor legislation and implement legal compliance. Legal compliance and the necessary organizational structures can be integrated into an environmental, health and safety management system (see section 3.4 on page 27), which requires similar procedures and organizational structures.

3.2 Handling of E-waste

Proper handling of e-waste is essential during collection, storage, transport and treatment. Equipment that is broken due to improper handling may cause severe environmental impacts or prevent re-use and adequate recycling. For example, the backlights in flat panel displays (FPDs) contain mercury. If the FPD is broken as a result of improper handling, the mercury may evaporate before the FPD can be properly treated. All EoL operators should handle e-waste in a way that prevents damage to the equipment that may cause environmental damage or preclude re-use or proper recycling. EoL operators should therefore be in a position to demonstrate that:

- They have trained their staff how to properly handle the different categories and types of e-waste.
- They have the infrastructure in place to enable the careful handling of e-waste.
- They put into practice damage prevention measures. For example, full containers coming onsite should not be emptied by simply tipping them over unless it is clear that the container does not contain e-waste that might be prepared for re-use or which might cause adverse environmental impacts if damaged.

EoL standards may stipulate specific requirements for the handling of e-waste where damages result in severe environmental impacts, or where damages make the subsequent treatment more difficult or even impossible. Examples for such equipment are:

- LCD FPDs with mercury-containing CCFL (cold cathode fluorescent lamp) backlights
- CRT monitors and TVs
- compact fluorescent lamps (CFLs, "energy saving lamps") containing mercury
- discarded refrigeration equipment containing HCFC, CFC and HFC with a high global warming and ozone depletion potential

3.3 Documentation of Material al Flows and Downstream Due Diligence

EoL standards shall compel EoL operators to document their activities, including the incoming and downstream flows of e-waste, components, fractions and materials thereof for monitoring and control of the operators' compliance with the standard. The operators shall hold the respective certificates, invoices and other confirmations necessary to prove compliance.

EoL standards shall hold EoL operators accountable for what downstream operators do with e-waste, components, fractions and materials forwarded to them.

Operators thus cannot delegate their responsibilities downstream, but must maintain control over the flows, including the selection of downstream operators who:

- Work according to the legal requirements.
- Have the technical, infrastructural and organizational structures in place that will enable them to meet the requirements and targets upstream operators must meet regarding the proper handling of the e-waste, components, fractions and materials passing through their facilities.
- Comply with other requirements and targets of the EoL standard, such as those regarding labour and social aspects, as well as financial liability, which the EoL standard clearly defines as being applicable to downstream operators.

EoL standards should require downstream due diligence and accountability for all downstream flows of e-waste, components, fractions and materials thereof as long as they are waste. [15] The responsible EoL operator should track these downstream flows until they become a product again or down to the final disposal.

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[15] European Commission, End of Waste Criteria. Available from http://ec.europa.eu/environment/waste/ framework/end_of_waste.htm (accessed 27 February 2012)

As a proof of compliance with the downstream due diligence and tracking requirement, standards should require EoL operators to document the types and amounts of downstream flows, as well as their fate.

As an important pre-requisite for documentation and tracking of material flows, each operator in the EoL-chain must have scales available on site adapted to the kind and amounts of e-waste, fractions or materials received from and handed on to other operators. E-waste, components and fractions thereof coming in and going out should be weighed, thus facilitating the comprehensive monitoring of the mass flows along the EoL chain.

3.4 Environmental, Health and Safety Management Systems

A properly implemented and operated environmental, health and safety management system (EHSMS) allows operators to identify and realize improvement potentials, and to continuously improve their performance. A fully implemented EHSMS also provides a structure for operators to implement the requirements of an EoL standard and to monitor compliance with the standard's requirements.

Standardized EHSMS are already available.[16] They cannot replace EoL standards but they should complement and support them. They are not specific for e-waste and do not set concrete EoL performance requirements. Given the rapid technological development, an EoL operator may continuously improve its environmental performance but still perform far below the state-of-the-art and the required quality level.

Nevertheless, EHSMS can be used to control the implementation of the requirements in an EoL standard and to identify and implement potentials for increasing efficiency. EoL standards should therefore recommend that operators have an EHSMS according to international standards.

However, EoL standards for EEE should not force operators to be certified according to such a standardized EHSMS. The actual reliability of the certificates is contested due to the certification rules and procedures (see section 6 on page 45), and the certification cost may be a high burden in particular for small size EoL operators. Independent of whether operators are certified according to a standardized EHSMS, EoL standards should demand that operators demonstrate their compliance with the requirements of an EHSMS and that they have the capabilities to ensure continuous compliance. EoL operators shall prove in particular:

- Tthey have all necessary infrastructural, technical, personnel and organizational capabilities and knowhow to identify and assess their relevant environmental, health and safety risks, and to effectively eliminate or continuously reduce them.
- They have actually and consistently set targets and achieved improvements in their environmental performance in the identified relevant areas over the period of time in which they have been operating under the EoL standard.

[16] For examples of EHSMS systems, see EMAS (http://ec.europa.eu/environment/emas/about/enviro_en.htm); the ISO 14000 series (http://www.iso.org/iso/iso_catalogue/management_standards/iso_9000_iso_14000/iso_14000_essentials.htm);OHSAS (http://www.ohsas-18001-occupational-health-and-safety.com/ohsas-18001-kit.htm); (accessed 19 February 2012)

3.5 Financial Liabilities and Insurance

If not already foreseen in the permits and other legal requirements for the facility, EoL standards should oblige EoL operators to have insurances covering damages to third parties, including:

- Environmental damages
- Impacts on the health of workers, neighbours and the general public
- Damages to workers', neighbours' and the general public's properties
- The orderly closure and clean-up of the site of operation

Insurance covering second party risks should not be mandatory in an EoL standard. Second parties are the business partners of EoL operators. They can decide themselves whether they are ready to accept the related risk if they do business with an operator that does not have an insurance covering second party risks.

3.6 Labour and Social Requirements

3.6.1 Assignment of Responsibilities and Training of Workforce

EoL operators shall be in a position to prove that responsibilities in their facilities are clearly assigned. Their staffs must be adequately trained and qualified to cope with the proper operation of the facility and to comply with the requirements and targets of the respective EoL standard.

Measures of verification may be organizational charts showing the company structures and responsibilities broken down to individuals, as well as plans for regular education and training. During conformity assessments, operators must allow interviews with workers in a manner ensuring confidentiality and avoiding future adverse consequences for participating employees.

3.6.2 Labour and Social Conditions

EoL standards should require fair payment, appropriate social and workplace conditions, and the absence of discrimination toward workers. Operators must prove that their employment contracts comply with the minimum legal occupational requirements with respect to payment, working time, occupational and safety training, medical monitoring, social security and respect for human rights.

For verification, EoL operators must allow auditors to check the working contracts, and to conduct interviews with staff in a manner ensuring confidentiality and avoiding future adverse consequences for employees.

Legal, economic and social conditions may vary considerably within countries and between different countries and regions. International social and labour standards could therefore be considered as minimum requirements and targets for labour and social aspects.[17]

[17] Examples of such standards are the Social Accountability International (SAI) Standard SA8000 (http://www.sa-intl.org/index.cfm?fuseaction=page.viewPage&PageID=1140&E:\ColdFusion9\verity\Data\dummy.txt) and the International Labour Standards (http://www.ilo.org/global/What_we_do/InternationalLabourStandards/lang--en/index.htm) of the International Labour Organization (ILO) (accessed 27 February 2012)

4 Requirements for Collection, Storage, Handling and Transport of E-waste

Collection, storage, handling and transport of e-waste shall prevent environmental and health damages. It should also enable the effective subsequent treatment of the collected e-waste. Aspects to be considered in this context are collection rates, the condition of the collected e-waste and the hand-over of the e-waste to appropriate treatment operators.

4.1 Collection of E-waste

E-waste collected separately from other types of wastes is more likely to undergo adequate treatment, thus preventing pollution and loss of resources. To achieve effective treatment, it is therefore essential that a high percentage of e-waste is collected separately. Standards for collection should hence require operators to take measures in order to achieve a high of e-waste being collected separately from other wastes.

4.1.1 Collection Service Requirements

In order to make it easier for consumers and retailers to hand in their e-waste for separate collection, standards should stipulate measures that bring collection facilities and collectors closer to consumers.

Collection standards may stipulate that collectors ensure the proximity of collection facilities to consumers. Collectors would have to provide a number of containers for the separate collection of e-waste in their collection area in particular for e-waste appliances, which consumers often dispose of with household waste (UNU 2008). Target density may be defined as containers per area depending on population density, or on a maximum distance within which consumers must find such a container or collection facility.

Smaller e-waste appliances may be collected together with other waste from private households if this is more economical. Such systems are already in practice[18], though their ecological benefit is debated (Buenemann 2011). It must be ensured that the e-waste can be separated at a later stage for further treatment and that the environmental, health and safety risks are not higher than from a separate collection. The benefits resulting from a higher collection rate of smaller e-waste should be taken into account as well in such an environmental and risk assessment.

Collection standards may require collectors to conduct periodical household collections of e-waste. It must, however, be taken into account that such collections may also attract informal collectors, leading to the export of e-waste to developing countries, as (Espejo 2010) has shown.

Collectors may be required to offer a “one stop service” for retailers in order to make it easier for them to give e-waste to appropriate operators. The retailer’s responsibility, then, would simply be to call the appropriate service provider, who would col-

[18] For examples of such systems, see Alba: Yellow Bin Plus, available from http://www.alba.info/ALBA_en/business/Entsorgung/Gewerbe/Wohnungswirtschaft/ALBA_Gelbe_Tonne_Plus.php, and BSR: Orange Box – die Wertstofftonne der BSR, available from http://www.bsr.de/11741.html (in German only); (accessed 8 May 2012

lect the e-waste and take responsibility for its proper handling from that point on.

4.1.2 Financial Incentives for Collection

Financial incentives may increase collectors' efforts to collect a higher share of the e-waste generated. Such requirements in an EoL standard would apply to those who contract the collectors, meaning that the contracting party also commits itself to requirements of collection standards. This would need, however, additional funds to cover the cost of such incentive programmes, such as a fee at the point of sale of new products which the waste collectors can use to finance their activities.

Public waste management authorities such as municipalities and retailers in many countries are major collectors of e-waste. They may be legally obliged to collect e-waste or to accept e-waste via trade-in agreements. The cost of municipalities may be covered by general waste fees or may even remain uncovered as it may be the case for retailers. Paying these collectors a fee for collection and handover of e-waste can provide strong incentives for both increased collection and transfer of e-waste to a state-of-the-art treatment scheme. By improving collection and appropriate transfer of e-waste, such payments may also contribute to a reduction of illegal export and improper handling of e-waste.

The reimbursement of collectors could follow a progressive tariff instead of a fixed amount paid per ton of e-waste collected. The tariff paid per ton of e-waste collected increases with the total amount of e-waste collected and handed over to the foreseen downstream operator (tariff A in Figure 2).

The progression of the tariff could take into account environmental priorities. For example, for e-waste containing hazardous materials or valuable resources, the tariff could start from a higher level of reimbursement and progress at a steeper rate, thus triggering greater collection efforts (tariff C in Figure 2).

The quality of the e-waste collection may be taken into consideration as well. Improper handling on the part of operators may lead to a reduction in reimbursements. For environmentally sensitive products, such as LCD flat panel displays, CFLs, fridges and cooling equipment containing HCFCs and CFCs, the reductions in reimbursements will be greater for damaged or mishandled e-waste (tariff B in Figure 2).

Collectors may also be required to pay a fee to consumers for turning in their e-waste. The producer or organization remunerating the collectors for this fee paid to consumers would have to reimburse collectors through direct reimbursements or by paying them higher rates per kilogram of e-waste collected.

In all cases a collection standard should only require the contracting parties to follow the incentive payment model with the progressive tariffs, but otherwise respect the contractual freedom of the contracting parties to set prices. The financial incentives and service requirements should be based on an eco-efficiency analysis in order to minimize cost and to achieve maximum cost-efficiency.

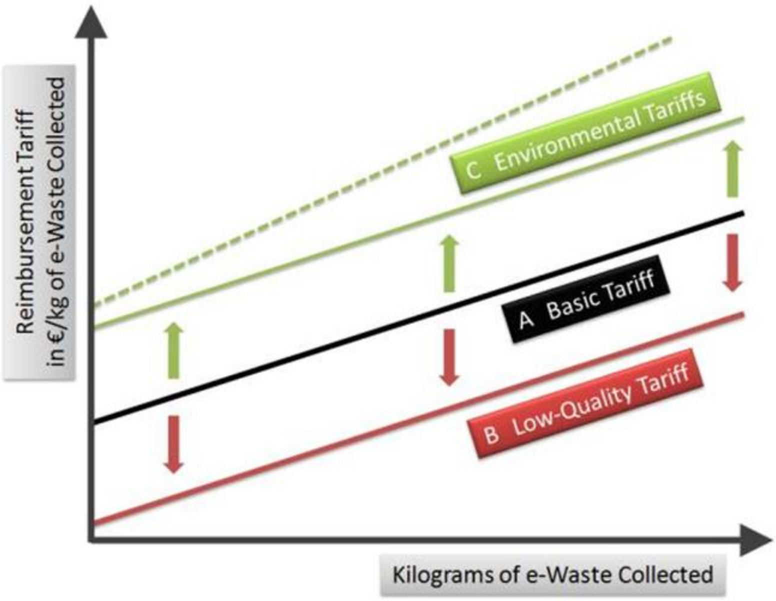

Figure 2: Reimbursement model providing collection incentives

4.1.3 Collection Targets

Standards for the collection of e-waste may set quantitative collection targets in order to ensure a certain minimum amount of collection, particularly in the absence of legislative requirements. Such a collection target may serve as a reference point for the incentive payment model illustrated in Figure 2.

Ideally, collection targets should be based on percentages of the weight of e-waste generated in the geographical area to which a collection standard applies. If such data are not available, an alternative reference point is the amount of EEE sold over a certain period in the past. The European (WEEE Directive 2012) is an example for such collection targets. The actual amount of e-waste to be collected would then have to be calculated every year.

Collection targets may also stipulate a fixed amount of e-waste to be collected per year, such as the four kilograms per inhabitant per year as suggested in the (WEEE Directive 2003). The amount of e-waste collected in previous years can serve as a baseline for setting realistic collection targets. The collection target should then be adapted periodically to make sure it remains in balance with the generated amount of e-waste. Finally, as a further possibility, a country's gross national product (GNP) may be used to estimate the amount of EEE that will be purchased and thus the amount of e-waste that will be generated in a given year (Huisman 2010).

In addition to setting general collection targets across all categories of e-waste, EoL standards may also set specific targets for e-waste types that are of particular environmental relevance, such as products:

- With high content of recyclable valuable materials, such as precious metals in mobile phones and computers.
- Containing scarce metals or other scarce materials, provided they can be recycled from these waste products.
- With a high potential to damage the environment, such as cooling and freezing equipment containing HCFCs or energy saving lamps containing mercury.

In all cases the collection targets must be realistic, meaning that collectors must be able to achieve them with reasonable effort. Quantitative collection targets should be based on a scientific environmental and economic cost-benefit analysis. In such a cost-benefit analysis, the environmental impacts (e.g. climate change due to energy consumption) and benefits (e.g. pollution prevention) related to e-waste collection must be balanced. Due to differences in infrastructural conditions and population density, the overall amount of e-waste generated, and technical treatment capabilities and know how, among other factors, the optimum collection rate may differ from country to country or from region to region. In setting quantitative regional collection targets, geographically non-specific EoL standards may provide a method for setting reasonable collection targets instead of stipulating a precise target.

4.2 Requirements for Storage, Handling and Transport of E-waste

4.2.1 Requirements Supporting Effective Treatment and Re-use

To enable re-use and effective treatment, standards should require operators to collect, store, handle and transport e-waste in a way that:

- Prevents damage to e-waste during these operations in order to avoid pollution due to breakage, leakage or corrosion.
- Does not hinder the removal and specific treatment of hazardous materials and components in subsequent downstream operations.
- Supports the sound re-use and recycling of e-waste, as well as the proper disposal or incineration of materials that cannot be treated otherwise.

The above targets require comprehensive monitoring and supervision of the storage and transportation of e-waste, thus necessitating that operators have adequate infrastructure in place to do so. Standards for storage and collection should therefore stipulate the following requirements:

- Transport vehicles and containers must be equipped to achieve the above targets. For example, containers that require e-waste to be thrown or dropped into them from top are not appropriate.
- Storage sites must be equipped to prevent pollution due to damage, leakage and corrosion. This may require measures such as sealed surfaces and weatherproof coverage of storage sites (WEEE Directive 2003).
- Each operator must weigh e-waste, including components or fractions thereof, coming in from or going out to other operators. This should prevent certain types of e-waste or components, such as old TVs or monitors that are economically less attractive to operators to be handed over to other operators outside the foreseen pathway.

With respect to provisions aimed at avoiding pollution from damaged or mishandled e-waste, EoL standards may stipulate specific requirements for the transport and storage of types of e-waste containing hazardous materials that may be released into the environment or where the subsequent treatment might be made more difficult. Examples of such equipment are:

- LCD flat panel displays with mercury-containing CCFL (cold cathode fluorescent lamps) backlights
- Compact fluorescent lamps (CFLs, "energy saving lamps") containing mercury
- Waste refrigerators containing HCFC, CFC and HFC, which contribute to global warming and ozone depletion

4.2.2 Requirements for Efficient Transport of E-waste

Because EoL operators often transport e-waste over long distances, it is important for the environmental performance of the entire EoL chain that their logistics operations are efficient, including the use of energy-efficient vehicles. A transport standard should hence require EoL logistics operators to follow a concept for environment-friendly logistics.

Sound logistics concepts can minimize transports and thus reduce the environmental impact of e-waste collection and treatment. There are institutes and companies offering the optimization of logistics networks as a service.[19] Standards for the transport of e-waste could thus require operators to develop a logistics plan for minimizing the distance driven in their collection and treatment of e-waste.

Organizations calling for tenders could require applicants to submit a logistics concept that outlines the measures they will take to minimize the environmental impact of their activities. In addition to the price of services, an environmentally optimized logistics concept could become an essential criterion for awarding contracts.

One way to significantly increase the overall efficiency of e-waste transport is to use more sustainable modes of transport, such as shipping and rail, rather than trucking (IEA 2010). Logistics transporters should, whenever possible, use environmentally-friendly modes of transport.

EoL logistics operators should use fuel-efficient, low-emission vehicles for all road-bound transports. Logistics operators should be obliged to use vehicles meeting stipulated efficiency and emission requirements, as determined by best available efficiency and emissions data, benchmarks and labels on light and heavy duty vehicles.[20] [21]

Driving style influences the energy efficiency and emissions of vehicles.[22] Ac-

[19] As an example, see Fraunhofer Institute for Material Flow and Logistics. Available from http://www.iml.fraunhofer.de/en.html (accessed 5 February 2012)

[20] Emissions from heavy duty vehicles (Euro VI): certification rules, http://europa.eu/legislation_summaries/internal_market/single_market_for_goods/motor_vehicles/motor_vehicles_technical_harmonisation/mi0029_en.htm (accessed 5 February 2012)

[21] Office for Energy Efficiency, Natural Resources Canada, http://oee.nrcan.gc.ca/transportation/business/reports/884 (accessed 5 February 2012)

[22] Office for Energy Efficiency, Natural Resources Canada,

cording to (IEA 2012), "eco-driving" contributes to better environmental performance of the transports used in the shipment of e-waste. [23] A transport standard should therefore oblige logistics operators to provide periodical eco-driving trainings to their drivers and to document this training with appropriate certificates.

EoL standards may require EoL logistics operators to provide information on the environmental impacts of their services. The standard should provide indicators, for example the carbon footprint and a framework for how to use them. Examples for such indicators are the fuel consumption related to the respective transport services, or the carbon footprint (ISO 14067, ISO 14069). EoL logistics operators can use to inform their contractors such as producer take-back systems on the environmental impacts of their operations and document their improvement over time.

5 Requirements for the Treatment of E-waste

5.1 Waste Hierarchy

To minimize the environmental impacts of waste, the following waste hierarchy should be applied:

1. Prevention
2. Preparation for re-use, and re-use
3. Recycling
4. Incineration with state-of-the-art flue gas cleaning and energy recovery
5. Incineration with state-of-the-art flue gas cleaning without energy recovery
6. Disposal on landfill sites

EoL standards should stipulate this hierarchy in their provisions. However, they must also consider potential confinements and additional factors when transferring it into precise requirements, as will be described in the following sections.

5.1.1 Preparation for Re-use and Re-use

The re-use of electrical and electronic equipment offers a number of environmental and social benefits. It saves energy and resources consumed in the production of new equipment, it reduces the amount of e-waste being generated and it may help reduce or avoid pollution from the inappropriate treatment of e-waste. Furthermore, people with low income, who might otherwise be unable to afford to purchase new equipment, may have access to low price re-used EEE. Nevertheless, environmental and economic drawbacks may hamper re-use.

Energy Efficiency as Limitation to Re-use

New equipment is in most cases more energy-efficient than older equipment. Re-using old equipment with considerably lower energy efficiency may thus increase energy consumption and greenhouse gas emissions. This applies in particular, but not only, to EEE for which the energy consumption in the use phase causes the main environmental impacts, such as cooling and freezing equipment. EoL standards and specific standards for re-use should hence consider setting limits and targets for the

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http://oee.nrcan.gc.ca/transportation/business/reports/884 (accessed 5 February 2012)

[23] Ministry of Transport, Public Works and Water Management (The Netherlands): Ecodriving as a policy to reduce emissions, 22 November 2007, International Transport Forum; http://www.iea.org/work/2007/ecodriving/netherlands.pdf, last accessed 5 February 2012

minimum energy efficiency of equipment for re-use. If scientific evidence indicates that its re-use would contribute to greater environmental impact than simply using new equipment, re-use should not be recommended. In many parts of the world, the energy efficiency of several types of EEE must be labeled.[24 25 26] Such labels can help inform the decision as to whether or not equipment should be prepared for re-use. Standards can, for example, exclude energy-inefficient devices from preparation for re-use and from re-use in order to minimize the overall environmental burden from EEE.

Market Limitations for Re-use

Equipment prepared for re-use needs markets. That is, it needs a population who will use second-hand equipment. Re-use requirements should hence reflect the market situation. Forcing operators working under an EoL standard to prepare for re-use whatever is technically possible to be re-used might create second hand equipment that cannot be sold.

Data Security

For information and communication technology (ICT) equipment, re-use presents data security concerns. Data on computers, mobile phones or other equipment with stored memory may be accessed and abused after its owner discarded it.[27] EoL standards therefore must set additional requirements for media sanitization. Reference to media sanitization standards or guidelines such as (NIST 2006) may be useful.

Because of these limitations on re-use, standards should not simply ask for the re-use of all e-waste that is technically reusable, but should stipulate clear conditions for re-use and take into account possible limitations.

5.1.2 Recycling and Disposal

Standards should require operators to avoid incineration and disposal of recyclable materials. Incineration or in particular, disposal of e-waste, materials or fractions thereof in many cases may be cheaper than recycling, thus setting economic incentives for disposal or incineration instead of recycling. This may result in resource losses and environmental burdens that may be avoided through proper recycling.

However, if sound scientific evidence indicates that treatment other than recycling yields a better environmental performance, EoL standards should deviate from the waste hierarchy.

For example, disposing of non-recyclable plastics in secured landfills might be the most environmentally-sound option in cases where state-of-the-art incineration facilities are not available in the region, as the

[24] European Commission: Energy Efficiency; available from http://ec.europa.eu/energy/efficiency/labelling/energy_labelling_en.htm (accessed 7 February 2012)
[25] United States Environmental Protection Agency (EPA): Energy Star; available from http://www.energystar.gov/ (accessed 7 February 2012)
[26] Energy Conservation Center Japan, Final Reports on the Top Runner Target Product Standards; available from http://www.eccj.or.jp/top_runner/ (accessed 7 February 2012)

[27] PBS, *Frontline*, "Ghana: Digital Dumping Ground", 23 June 2009. Available from http://www.pbs.org/frontlineworld/stories/ghana804/video/video_index.html (accessed 27 February 2012)

environmental costs of transporting the e-waste to distant incineration plants may outweigh the benefits of doing so. The same might apply if the recycling of materials from e-waste consumes high amounts of energy or other resources, but only yields low-quality secondary materials, as may be the case with mixed plastic fractions from e-waste treatment.

Standards should require operators to use disposal and incineration facilities according to the best available technology for fractions, materials and components from e-waste that cannot or should not be treated otherwise. If operators demonstrably have no access to such facilities, standards should require the use of the highest standard disposal and incineration facilities available in the respective region.

5.2 Removal and Separate Treatment of Hazardous Materials and Components

Pollution prevention is a main objective of e-waste treatment. E-waste containing hazardous materials or certain components requires specific treatment to prevent pollution. Examples of such materials and components include:

- Mercury in backlights of LCDs and in compact fluorescent lamps ("energy saving lamps")
- Capacitors containing polychlorinated biphenyls (PCB) (SENS 2008)
- Older cooling and freezing equipment containing HCFC and CFC as cooling agents
- Lead and cadmium in electronic and electrical components, as well as the brominated flame retardants PBDE and PBB with a high dioxin and furan potential[28]
- Batteries

Some materials and components containing such materials need to be removed from e-waste and be treated separately to avoid pollution, as for example stipulated in Annex II of the (WEEE Directive 2003).

EoL standards shall clearly define hazardous materials and components to be removed from e-waste.

"Removal" does not necessarily mean disassembly and manual separation. The (WEEE Directive 2003) defines removal as manual, mechanical, chemical or metallurgic handling with the result that those hazardous materials and components are contained as an identifiable stream or identifiable part of a stream at the end of the treatment process. A material or component is identifiable if it can be monitored to ensure its environmentally-safe treatment.

Hazardous components and materials can be removed:

- In an initial treatment step, prior to further processing such as shredding and mechanical separation (initial removal For example, this may be accomplished by disassembling the e-waste device and manually removing components containing hazardous materials.
- During or at the end of subsequent processes (process-integrated removal).

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[28] The European Directive 2011/65/EU (Restriction of Use of Certain Hazardous Substances, RoHS Directive) bans these materials in EEE put on the market after June 2006. Due to exemptions in the RoHS Directive, however, these materials are still present in EEE, though in much lower concentrations than in EEE put on the market before July 2006

Following the principle of target orientation, treatment standards should indicate the desired result and allow operators to determine how best to achieve this target.

5.2.1 Criteria for Initial and Process-integrated Removal of Hazardous Materials

In order to prevent pollution and enable adequate treatment of e-waste, standards should stipulate that materials or components have to be removed from e-waste prior to any further treatment if at least one of the following conditions applies:

- Hazardous materials or components cannot be controlled in subsequent treatment processes and therefore may be released into the environment during the treatment processes or from the resulting fractions or materials.
- These materials or components otherwise hinder high-quality recycling from e-waste in the initial or downstream operators' activities.
- These materials or components otherwise disturb treatment processes of e-waste, fractions or materials thereof in operations of the initial or downstream operators.
- These materials or components otherwise end up in incineration or landfill sites that are not equipped to accept and properly dispose of them.
- These materials or components would otherwise end up in incineration or landfill sites, even though recycling or other treatment would be more environmentally sound options.

A process-integrated removal of hazardous materials and components from e-waste is sufficient if:

- They can be controlled, isolated and removed safely in or after the process to a degree comparable to prior removal.
- If these removed hazardous materials subsequently can be treated, incinerated or disposed of in a way preventing pollution to a degree comparable to the initial removal of these materials and components from e-waste.

5.2.2 Separate Treatment of Hazardous Materials

EoL standards should specify clear provisions regarding the separate treatment of removed hazardous materials and components in order to achieve the following requirements and targets:

- During or after removal, hazardous materials and components should be treated according to the hierarchy of treatment targets. Recycling of hazardous materials such as mercury should be prioritized if the release of these materials into the environment can be prevented.
- The separate treatment of hazardous materials and components may also occur within a process – that is, without initial removal – so long as it identifies the flow and fate of the hazardous materials and components. This process should either eradicate the hazardous physical and/or chemical properties or otherwise facilitate the control over these materials and components. They should either be recycled, incinerated, or prepared for disposal or incineration.

If possible, hazardous materials and components that cannot be recycled and must be disposed of should be rendered inert in such a process.

- Incineration and final disposal should only be allowed in facilities that are equipped to handle such materials and components in a manner that avoids emissions into the environment.
- If physically possible, incineration should be conducted in incineration plants with energy recovery capabilities.

5.2.3 Control and Incentives for Removal and Separate Treatment

Leaving freedom to EoL operators to decide whether to employ initial or process-integrated removal of hazardous materials and components, requires strict and stringent control and monitoring of resulting waste quantities and qualities. EoL standards must compel operators to clearly demonstrate that they actually remove hazardous materials and components from the waste stream and that they treat these materials effectively in order to prevent pollution in their daily operations.

- EoL operators shall track and document the downstream flow and fate of hazardous materials and components (see section 3.3 on page 26). Documentation shall include the amounts and categories of incoming e-waste, the amounts of materials and components actually removed from this e-waste and evidence of their correct treatment according to the above principles.
- The types and amounts of hazardous materials and components removed from e-waste should be in a plausible ratio to the types and amounts of incoming e-waste, as based on the average age and composition of e-waste collected and treated within the area or region in which the standard shall be applied. Unannounced audits may be useful to monitor daily compliance.
- The proper removal, treatment and disposal of hazardous materials and components increases operators' costs. There is thus an economic incentive for operators to minimize or even forego the removal of these materials. Standards should therefore require those contracting the treatment operators to provide economic incentives for proper removal. Payments to operators for the amounts of such materials and components removed and demonstrably treated or disposed of adequately would create an economic incentive for compliance.

5.3 Recycling Targets

Recycling targets set minimum quantitative thresholds for the amount of materials to be recycled from treated e-waste. In the absence of legal regulations, it makes sense to stipulate recycling targets in order to achieve a certain level of effectiveness in the recycling of e-waste.

5.3.1 Types of Recycling Targets

Recycling targets can be set in different ways, including:

1. General percentages of the treated EEE's weight or specific percentage targets for different categories of e-waste, as outlined in the (WEEE Directive 2003)

Equation *5* illustrates this recycling rate *R* as ratio of the mass m_r of materials counted as recycled and the mass m_{in} of the e-waste input into the pre-processing and recycling process:

$$R = \frac{m_r}{m_{in}}$$

Equation 5: Simple mass-based recycling target

Such a target is simple and easy to control. Batch tests may be used for the compliance assessment (see section 5.3.3 page 41). The disadvantage is that all materials are considered as environmentally equal. Environmentally and from the resource point of view it makes, however, a huge difference whether one gram of iron or one gram of gold is recycled from e-waste (Huisman 2003). Precious metals require much more energy in mining and refining and are also much scarcer than more common metals such as iron. Because e-waste contains only small amounts of precious metals (e.g. gold) and hazardous metals (e.g. lead), EoL operators may fully comply with the recycling targets without recycling any of the ecologically and economically most valuable materials (Chancerel 2010).

2. Ecologically weighted mass percentages to be recycled from specific categories of e-waste

Using an ecological weighting method, the mass of materials can be modified with an ecological weighting parameter:

$$m_{eco} = m_i \cdot e_i$$

Equation 6: Ecologically weighted mass of materials

The ecological weight m_{eco} of a material i is the product of its physical weight m_i and its material-specific ecological weighting parameter e_i. Such ecological weighting values can be based on life cycle inventory assessments. The value of e_i increases with the ecological value of the material. For example, it would be much higher for gold than for iron. Modifying Equation 5, the ecologically weighted recycling rate R_{eco} can be mathematically expressed as:

$$R_{eco} = \frac{m_{ri} \cdot e_i}{m_{in,i} \cdot e_i}$$

Equation 7: Ecologically weighted recycling rate

In addition to the total mass of the e-waste devices going into and coming out of an EoL recycling process, the material composition of the e-waste must be known in order to calculate the total ecological mass of the e-waste device and the recycled materials. Average composition data could be assumed for the e-waste devices and the resulting fractions could be analyzed, as is done in batch-testing recyclers' recycling performance (see page 41). Finally, this method would require an agreement as to which method to use to derive the ecological weighting parameter e_i. There are several life cycle assessment methods and other methods[29] but there is currently no standard method for deriving an ecological weighting parameter.

[29] For examples of life cycle assessment methods, see Total Material Requirement (TMR), available from http://www.wupperinst.org/); the LCA software GABI (http://www.gabi-software.com/america/index/);SimaPro (http://www.pre-sustainability.com/content/simapro-lca-software); and Umberto (http://www.umberto.de/en/); (accessed 26 February 2012)

Using ecologically weighted recycling targets would differentiate materials according to their ecological value (Huisman 2003). Recycling one gram of gold would thus result in a higher recycling rate than recycling one gram of iron. The target should be to recycle as much as possible of the ecologically critical materials at economically reasonable expenses in order to achieve a high eco-efficiency. As the content of ecologically critical materials like precious metals varies between different categories and types of e-waste, such a recycling target should only be used for those categories of e-waste with high contents of such materials. Setting recycling targets for precious metals in waste IT equipment with high precious metal contents makes sense, whereas a simple mass-based target might be sufficient for appliances like washing machines and dishwashers.

5.3.2 Approach for the Setting of Recycling Targets

The following approach is recommended for the setting of recycling targets:

1. Focus on environmental priorities

Recycling targets should aim to both maximize the amount of environmentally valuable materials (e.g. precious metals) available in the technosphere and to ensure that they recycled to the highest possible quality for their use in new products. The same applies to hazardous materials (e.g. lead) if they can be controlled and used again in the technosphere (see section 5.2.2 on page 37 on separate treatment).

2. Consideration of all subsequent recycling processes

Recycling is sub-divided into pre-processing and end-processing. Pre-processing includes activities such as disassembly, shredding, mechanical separation of e-waste. End-processing are processes such as smelting and refining in smelters to recycle materials from components and fractions produced in pre-processing. The aim of the pre-processing activity is to allocate each material in an e-waste device to a fraction from which it can be recycled in subsequent end-processing. (Deubzer 2011)

The success of pre-processing can be measured as yield r_n in percentage of the weight of a certain material in an e-waste device that is allocated to a fraction from which it can be recycled in end-processing. The end-processing process has a yield of r_{n+1} in percentages of the amount of materials contained in the fraction entering the end-processing process. The overall recycling rate for a specific material, for example gold, is the product of the yields of each single process *n* in the EoL process chain. For a recycling process chain consisting of a given number *n* of pre-processing and recycling processes, the overall recycling rate *R* for this material would be:

$$R = \prod_{n=1}^{z} r_n$$

Equation 8: Calculation of the overall recycling rate in a sequence of EoL processes

For an EoL process chain of three processes with 10 % yield r_1 in the first pre-processing step and 60 % yield r_2 in the second pre-processing step and 95 % yield r_3 in end-processing, the overall gold recycling rate R would be

$$R = r_1 \cdot r_2 \cdot r_3 = 0.1 \cdot 0.6 \cdot 0.95 = 5.7\ \%$$

The example shows that the recycling performance is the result of the performance of each single process with the weakest process having major influence on the total result. Recycling targets r_i should therefore be set for each process in a sequence of several processes or at least for those processes with the lowest performance in order to increase the overall performance.

3. Provision of clear rules for the calculation of recycling rates

EoL standards shall provide EoL operators with clear rules and guidance for the calculation of the recycling rates as a result of their EoL operations. This will help avoid misinterpretations and fraud. The calculated recycling rates are then comparable between different EoL operators, creating a level playing field and spurring competition to improve performance.

4. Orientation at BAT

Recycling targets should be derived from best available technologies (BAT) and best practices [30] (see section 2.1 on page 19 about target orientation).

5. Consideration of the overall environmental optimum

Recycling operations also consume resources, such as energy and water. Such resource consumption and other environmental impacts may increase disproportionately with the recycling rates. The environmental benefits of recycling targets therefore must be balanced with the environmental impacts of recycling processes.

6. Consideration of eco-efficiency

Recycling operations yield saleable secondary materials and environmental benefits through resource conservation and pollution prevention. However, recycling operations also cost money and inadequate recycling targets may lead to very high economic costs so that the expenses are difficult to justify. Recycling targets must balance the environmental benefits and economic costs of recycling operations. The target should be the highest possible eco-efficiency, wherein excellent environmental performance is achieved at moderate cost.

5.3.3 Assessment of Conformity with Recycling Targets

Batch tests and mass balances are methods and tools to assess recyclers' compliance with recycling targets. Batch tests can assess the operators' principal technical and procedural capability to actually achieve the recycling targets. In a batch test, a certain amount of e-waste of known composition is treated in a recycling process, such as the shredding and mechanical separation of materials into fractions. The resulting fractions are then analyzed to determine which materials can be recycled in downstream operations or, perhaps, may already be counted as recycled.[31] The result of the analysis indicates whether the recycler has the technological ability and the knowhow to achieve the stipulated recycling targets.

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[30] European Commission Joint Research Centre, Institute for Prospective Technological Studies. Available from http://eippcb.jrc.es/reference/; (accessed 26 February 2012)

[31] As an example, see WEEE Forum: WEELABEX Treatment Standard, Annex C (Batch Testing); http://www.weee-forum.org/weeelabexproject; (accessed 7 May 2012)

Mass balances enable the comparison of incoming e-waste with outgoing components, fractions and materials. This allows for plausibility testing to determine whether an operator uses its technology and knowhow to conform to the recycling targets in its daily operations. Non-compliance may be detected through discrepancies between the input and output of materials or in the ratio of the various output streams.

5.4 Transboundary Shipments and Prevention of Illegal Exports

Illegal transboundary shipments, wherein e-waste is illegally shipped across national borders, present a significant challenge to attempts to regulate and monitor e-waste. The adverse effects and consequences of illegal exports to developing countries and to countries with economies in transition are well known.[32] EoL standards should therefore set specific stipulations against illegal transboundary shipments of e-waste.

5.4.1 Legal Requirements for Transboundary Shipments

The legal requirements and conditions for transboundary movements of e-waste may differ from country to country. Thus, the definition of what constitutes "illegal export" is not uniform:

- The legislation of exporting countries differs in terms of the legality of exports of e-waste, components, fractions and materials thereof to other countries, in general, and to developing countries and countries with economies in transition, in particular.
- The legislation of importing countries differs in terms of the legality of imports of e-waste, components, fractions and materials thereof.
- Legislation differs between countries in regards to what types of e-waste, materials or fractions thereof may be shipped across national borders.
- Legislation differs between countries in terms of the purposes for which e-waste, components, fractions and materials thereof may be shipped across borders, e.g. only for re-use, for recycling, incineration or for disposal.
- Definitions demarcating "e-waste" and waste derivatives from "product" are different as well in the countries. It is difficult to draw a clear line in the EoL treatment chain between the waste status and the product status of a device, component, fraction or material.

The (Basel Convention) is the most comprehensive international framework agreement on transboundary movements of wastes. Beyond the Basel Convention, there is no internationally agreed upon standard for transboundary shipments.

- EoL standards should therefore stipulate compliance with the Basel Convention as a minimum requirement. This provision should apply regardless of whether operators applying the EoL standard are located in a country that has adopted the provisions of the Basel Convention into its national legislation.

EoL standards should stipulate further measures to prove the legality of exports.

[32] PBS, *Frontline*, "Ghana: Digital Dumping Ground", 23 June 2009. Available from http://www.pbs.org/frontlineworld/stories/ghana804/video/video_index.html (accessed 27 February 2012)

- EoL operators working under an EoL standard must hold all legally required documents and permits for any transboundary shipment of e-waste, components, fractions or materials thereof (also see chapter 3.1 on page 25 about legal compliance). These documents and permits shall be available from the sending and the importing country, as well as from transfer countries.
- EoL operators shall document the type and amounts of incoming/outgoing e-waste, re-used equipment, components, fractions and materials (mass balances) and apply downstream due diligence, tracking and documentation down the whole EoL chain to the final destination (see chapter 3.3 on page 26 about documentation). This shall create transparency regarding the actual fate of these devices and materials.

5.4.2 Re-use and Illegal Exports of E-waste

Illegal exports of e-waste to developing countries and countries with economies in transition often occur under the guise of "re-use". Used EEE is labelled as equipment for re-use, even though it is not in a condition that allows for its re-use. A major challenge in monitoring and regulating transboundary flows of e-waste is how to differentiate illegal exports from used products that are actually intended for re-use.

To avoid illegal exports, equipment for re-use must be sufficiently functional and its transport and storage must meet all requirements to maintain this functionality.

Operators hence shall:

1. Identify equipment in the e-waste stream that is in adequate condition to allow for its re-use
2. Properly test and document the functionality of any equipment prepared for re-use
3. Properly package, store and transport the equipment identified and prepared for re-use so that it maintains its functionality
4. Demonstrate that they have the infrastructure, technologies and knowhow to comply with the above requirements
5. Provide invoices or equivalent documentation from the person or body that purchased the equipment prepared for re-use
6. In case of transboundary shipments, provide clear evidence that the shipment is legal
7. Only pass along equipment that is to be re-used or prepared for re-use to operators that meet the above requirements and any other provisions of a treatment standard that shall prevent illegal exports. Operators shall properly document the flows all such materials (see section 3.1 on page 25 on legal compliance)
8. Operators not meeting these requirements should not be allowed to prepare equipment for re-use or export any used EEE to developing countries and to countries with economies in transition

Some producers of EEE with global business models repair and re-use their own equipment, in particular professional equipment such as information and communication technology equipment (Gensch 2009). They have repair and refurbishment facilities in some countries, to which they transport equipment for repair, refurbishment and re-use from other parts of the world. Once repaired and refurbished, the equipment is redistributed. In such cases, the above requirements could block the repairs and re-use of equipment if the producer works under an EoL standard.

The above requirements in an EoL standard therefore should not apply if a producer or a producer-authorized entity ships its own brand equipment for re-use to a producer- authorized repair centre. The producer should be held fully responsible for the legal compliance of the exports and all the operations and must demonstrate this compliance with the appropriate documentation and permits. The producer should also demonstrate that equipment intended to be treated for re-use, repair and refurbishment is not disposed of or treated in any manner other than for its intended purpose. The equipment shall be fully traceable to the point where it is put on the market again as used EEE.

5.4.3 Requirements for Legal Transboundary Shipments

Even legal transboundary shipments may not comply with an EoL standard. EoL standards should stipulate strict and clear requirements for transboundary shipments. EoL operators shall demonstrate that the following conditions apply:

- E-waste, components, fractions and materials thereof are transported, stored, handled and treated under conditions that provide a level of environmental, health and safety (EHS) protection at least comparable to the country in which the e-waste arose.
- Any waste residues resulting from the above operations in the country of import are transported, stored, treated, incinerated or disposed of in a manner that maintains a level of EHS protection at least comparable to the country in which the e-waste originated.
- All applicable requirements and targets for transport, storage, treatment and other applicable provisions in the EoL standard are achieved and there is documentation giving clear evidence of this.

Purely treating a fraction of e-waste in a developing country in a plant that meets the state-of-the-art requirements in the country of origin of the e-waste thus may not be enough to justify the export of components, materials or fractions of e-waste. If wastes resulting from this treatment cannot be recycled, incinerated or disposed of properly in the sense of the EoL standard, an EoL standard should prevent such exports.

The burden of proof must be with the operator initiating the export and according to the downstream due diligence requirement with the accountable upstream operator.

Provided these shipments are legal, EoL standards should, however, allow transboundary shipments of e-waste, components, fractions or materials thereof to countries and operators where the same or better EoL performance can be achieved under comparable or lower health and safety risks.

5.5 Efficiency of Treatment

The treatment of e-waste saves resources and prevents pollution. However, it also causes environmental burdens such as energy and water consumption, noise, emissions and wastes. In addition to the effectiveness of treatment, the efficiency of treatment is crucial in minimizing the overall environmental impacts of the treatment processes (see section 2.6.2 on page 23 about efficiency).

Some countries have legal limits for emissions into the air, soil and water, as well as for noise, in their environmental and occupational health regulations. Beyond compliance with legal emission limits, setting targets for efficiency in EoL standards is not advisable. Operators' processes, infrastructure, organization and boundary conditions even within the same region may be widely different and there may be trade-offs. For example, a technology with excellent energy efficiency may have high water consumption.

Rather than set efficiency targets, EoL standards should require operators to assess and continuously improve their efficiency. Benchmarks and performance indicators are useful tools to assess the status of environmental hot spots and their improvement over time (see Parmenter 2010, ISO 14046). Environmental screening tools and indicators such as carbon footprints (ISO 14067, ISO 14069) and water footprints (ISO 14046) may be used to evaluate operators' specific environmental impacts and their changes over time. These indicators may be used to examine an operator's impact and efficiency from a number of perspectives. For example, they may be used to assess the energy or water consumption per amount of e-waste treated or per unit of monetary value generated. Eco-efficiency approaches Huisman 2003) can be applied to optimize the economic and environmental benefits of treatment.

The selection of indicators and tools, and the assessment and continuous improvement of efficiency can be incorporated into an operator's environmental, health and safety management system, which all operators should have installed (see section 3.2 on page 25). The training of staff required for the correct use of the efficiency parameters and tools can also be organized and supervised within an operator's EHSMS.

6 Conformity Assessment of EoL Standards

6.1 Third Party Conformity Assessment

Conformity assessments (CA) must reliably demonstrate that EoL operators actually comply with the requirements of a standard, as otherwise high quality standard are useless. ISO 17000 differentiates first, second and third party conformity assessments.

- First-party conformity assessment

  Conformity assessment that is performed by the person or organization that provides the object or service (ISO 17000); in the EoL chain of e-waste, this would be an EoL operator. After a successful self-assessment, the operator can issue a "declaration of conformity" (ISO 17000).

- Second-party conformity assessment

  Conformity assessment that is performed by a person or organization that has a user interest in the object or service (ISO 17000); in the EoL chain of e-waste, this would be any body contracting an EoL operator, such as a producer who has the producer responsibility for the EoL of its products.

- Third-party conformity assessment

  Conformity assessment performed by a person or body that is independent of the person or organization that provides the object or service and of user interests in that object or service (ISO 17000). After a successful third-party assessment, the third party issues a certificate stating that the assessed operator complies with the requirements and achieves the targets of the EoL standard. According to ISO 17021, the overall aim of certification is to give confidence to all parties that a management system meets specified requirements. The value of certification is the degree of public confidence and trust that is established by an impartial and competent third-party assessment.

Pollution prevention and resource saving are of high public interest given the severe environmental and health impacts and the generally increasing scarcity of resources related to non-compliance. EoL operators who do not comply with EoL standards may cause environmental pollution, loss of valuable natural resources and increased health risks. Next to high quality standards, a sound conformity assessment system therefore is of outstanding importance. The auditing and certification of EoL standards therefore must be organized in a way that systemic conflicts of interests are prevented as far as possible for the auditors conducting conformity assessments as well as for the private or public bodies offering these services.

EoL operators complying with EoL standards may increase their costs of operation. For example, properly removing specified hazardous materials or components from e-waste often requires a significant investment of labour, time and energy. Non-compliance is often overlooked in self-monitoring, as it is against the self-interest of the operator. Indeed, the competitive pressure on operators to offer their services for low prices in many cases conflicts with the additional costs required for high quality treatment. Due to this potential for conflicts of interest to compromise the quality of assessments, first party conformity assessments are not appropriate for the auditing of EoL operators.

Auditing of EoL operators by second parties, such as producers and producer takeback schemes, may also suffer from conflicts of interest. Second parties are interested in acquiring the services of EoL operators for the lowest price. In the absence of proper third party monitoring and control, a second party may benefit from the reduced costs and competitive advantages provided by an EoL operator's non-compliance. Second parties are thus in a systemic conflict of interest. Second party conformity assessments are not the appropriate approach to achieve reliable conformity assessments of EoL standards.

There are, of course, EoL operators, producers and producer takeback systems dedicated to high environmental performance. Conformity assessments must, however, in particular be conducted to identify those who do not meet the requirements of an EoL standard.

Due to the high likelihood of conflicts of interest compromising first and second party conformity assessments, third party conformity assessments of EoL standards are therefore the systemically most reliable CA system. A reliable third party CA system must:

- Prove that an EoL operator actually complies with the requirements of an EoL standard.
- Ensure that a second party, e.g. a producer or takeback system, contracts EoL operators that actually comply with the respective EoL standard.

- Protect the interests of EoL operators who comply with standards to ensure that their compliance does not put them at a competitive disadvantage against non-complying operators.
- Protect the interests of those auditing and contracting EoL operators that conform to a standard against those who do not give priority to their EoL operators' performance and conformity to an EoL standard.
- Protect the public from adverse impacts on the environment, health and safety arising from inadequate collection, transports, storage and treatment of e-waste.
- Satisfy the public interest in having a verifiable high EoL performance level in the collection, storage, transport and treatment of e-waste.
- Protect the knowhow and business secrets of operators, who may rightly be reluctant to disclose this information to second parties – their clients – even though it may be necessary during an audit. A third party certification may help to accommodate all needs of all stakeholders.

Third party conformity assessments and certification are therefore recommended to complement the implementation of high quality EoL standards. In the course of due diligence, second parties should additionally monitor and control the performance of their EoL operators and they should require EoL operators to only cooperate with EoL operators working under a high quality standard with a reliable third party conformity assessment system.

6.2 Design of a Reliable Third Party Conformity Assessment System

ISO 17021 stipulates the essential qualities of third party CA bodies and auditors:

- Impartiality
- Competence
- Responsibility
- Openness
- Confidentiality
- Responsiveness to complaints

Any CA system must ensure the above qualities of the CA bodies and auditors, as they are essential for the reliability of the CA.

6.2.1 Limitations to Auditors' Independence and Impartiality

The impartiality and actual independence of a third party CA body and its staff conducting the CAs, the auditors, is of crucial importance as it is the distinguishing factor that adds value to third-party CAs in comparison to first- and second-party CAs.

The actual independence of the auditors is difficult to verify. This applies in particular to the financial independence of the CA body and its auditors from the assessed first party, especially if the first party reimburses the auditor for the audit. The situation might be similar if a second party pays for the audit. If, in a competitive market, the first or second party may select the CA body performing the CA, the CA body's and the auditors' independence is compromised. In cases where the first or second party reimbursing the CA body for its work is not satisfied with a negative result of the audit, it will choose a different

CA body the next time. Over the medium- and long-term, this loss of revenue may put the CA body's economic survival at risk. This financial dependence benefits producers and operators by not only preventing unfair, overly critical audits but by incentivizing auditors to produce positive auditing results in order to be selected again for subsequent audits and not to be driven out of business. This situation reduces the credibility and trustworthiness of the third party CA and the certificate.

6.2.2 Proposal for a Third Party Conformity Assessment System

In cases where the CA body is selected and directly paid by the audited party, there should be an additional control system monitoring auditors' performance. This monitoring body should be independent from the CA body as well as from the first and the second party. It could be a governmental body or an accreditation body. This body should make frequent onsite audits of the EoL operators that the auditor has audited in order to judge whether the auditor's assessment accurately reflects the quality of operations of the audited EoL operator. Simply controlling the auditor's documentation of audits he or she has performed is not sufficient. Depending on whether the auditor's audit was announced or unannounced, the control audit should follow the same protocol to ensure comparability.

Another option would be to avoid such conflicts of interest systematically and to install a CA system that prevents EoL operators or second parties from selecting and reimbursing their auditor or the CA body. A draft model for such a CA body is proposed in Figure 3.

The CA body is independent from EoL operators, producers of EEE, takeback systems or any other second party in the EoL chain of EEE. The CA body can be organized in the public or in the private domain.

1. Financially, the CA body is based upon annual payments of EoL operators that work under the EoL standard. The EoL operators are audited and certified according to this EoL standard. The CA body would select and pay the auditors for auditing the operators.
2. To keep costs low, the CA body may use qualified external auditors. The CA body should call for tenders periodically. Other CA bodies could then compete to do a certain amount of audits for a certain price and the CA body selects the best offers.
3. If an operator needs to be re-audited, or if it wants to apply for the first time for a certificate, it must contact the CA body for an audit.
4. The certification office, not the operator to be audited, appoints an auditor from one of the companies that work for the CA body (RAL 2007).
5. The auditor audits the EoL operator and informs the CA body of the result.
6. After receiving confirmation from the auditor that the operator complies with the standard, the CA body issues a certificate of compliance.
7. In addition to regular audits, the CA body should initiate random unannounced visits of auditors on EoL operators' premises in order to monitor the EoL operators' actual daily conformity.

In order to prevent first or second parties from selecting different CA bodies for the assessment of their conformity to specific

EoL standards, thus creating downward competition, only one such CA body per country or region should be entitled to perform CAs for a specific EoL standard. This will enable the credibility of the CA and the certificates for conformity with this specific standard to be maintained at a high quality level.

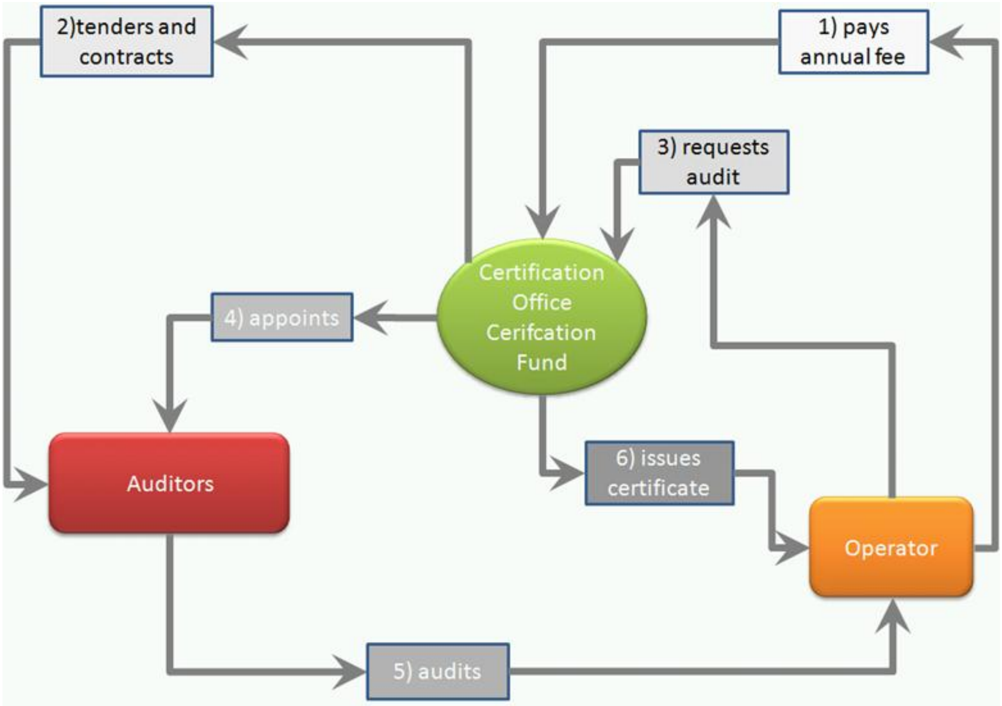

Figure 3: Example of organization of auditing and certification

As compensation for this monopolistic position, the CA body should be organized as a non-profit organization. To prevent that CA bodies, themselves, from compromise on the quality of their audits in order to keep down costs, CA bodies should be accredited and supervised by an accreditation body. The accreditation of CA bodies is internationally most renowned to prove a CA body's qualification, because accreditation bodies as independent bodies authorized by governments have credibility in the supervision of CA bodies.[33] It is recommended to design an independent third party CA system, wherein third parties meet the criteria for independence and to accredit this CA system and the CA body.

Conformity assessments should be conducted periodically to maintain the validity of operators' certificates. Two to four years should be an adequate interval balancing the expense of assessments and the need to monitor operators' conformity. As a surveillance measure, additional audits are necessary if the operator changes his processes or organization or expands his activities to a new category of e-waste (ISO 17000).

33 International Accreditation Forum (IAF); available from http://www.iaf.nu/ (accessed 26 February 2012)

Standards should define short-term deadlines for achieving compliance in cases where audits reveal that operators are failing to comply with requirements and targets. Longer-term deadlines would endanger the level playing field by allowing some operators to unfairly benefit from their non-compliance and thus obtain competitive advantage. If operators repeatedly fail to comply, they should be considered as non-compliant and lose their certificate. Otherwise, temporary compliance could become a strategy, which would allow operators to avoid the costs and administrative burdens of long-term compliance while still maintaining their certificate of compliance.

Along with periodic scheduled audits, conformity assessments should include unannounced control audits in order to monitor EoL operators' daily compliance between scheduled audits (ISO 17000).

The combination of a high quality EoL standard with a reliable CA system ensuring that EoL operators actually comply with the standard's requirements can thus be a valuable contribution to improve the e-waste problem.

7 Application and Harmonization of EoL Standards and their Certification

Several standards are in preparation or already available. Examples for national and regional standards are the (R2 2008) and the (e-Stewards 2011) standards, both developed in the United States, the (WEEELABEX 2011) standard set up in the European Union and the (China National Standard 2011). Local standards have been installed as well, such as the (E-Cycles 2008) standard in Oregon in the USA. Individual producers and producer organizations have also established standards, such as the (Ecoped Standard 2010). Finally, international organizations have published recommendations for EoL standards, such as the (Basel Convention 2011). However, an internationally acknowledged standard or framework standard is still missing.

Standards and the related CA systems are set up by public or private bodies or groups, which then promote their standards and CA systems to be applied. If several standards are available, there will be competition on which standard shall be applied. The result may be friction between stakeholder groups in the short-term and possibly downward competition on the quality of the standards and certification rules in the long-term, as the establishment, compliance with and monitoring of reliable EoL standards causes additional cost.

If second parties – producers, take-back schemes and other bodies contracting EoL operators – insist on certain standards to be used, EoL operators may have to be certified according to several different standards to remain in business. This situation would increase bureaucracy and costs disproportionally to the benefits it yields.

It is therefore proposed to instigate a process that would promote the development and harmonization of high quality EoL standards on national and international level.

7.1 List of Qualified EoL Standards and Certification Systems

Producers or other bodies should accept EoL standards with related CA systems that meet specific qualification criteria ensuring a high quality level of EoL standards. Such qualification criteria may, for example, be derived from this paper. EoL standards and CA systems meeting these criteria may thus be identified and put on a list of qualified standards. Second parties can then make contracts with EoL operators working under a standard, which has been qualified for the operators' region or country of operation. Table 1 gives an example of such a qualified standards list.

Table 1: Example list of qualified standards and related certification assessment systems

	Country/Region X	Country/Region Y	Country/Region Z
Qualified Standards	EoL Standard A	EoL Standard A	EoL Standard B
	EoL Standard B	EoL Standard C	EoL Standard C

The list may include, for example, a particular set of national standards and CA systems A and B for Europe and another set A and C for the United States. A global producer of EEE can require European EoL operators to be certified according to either standard A or B in Europe or to standard A or C for EoL operators that operate in the United States. EoL operators, however, should have the freedom to select standards applicable in their region from the list. They should not be forced into operating under one single standard.

The standards on the list would also be helpful for transboundary cooperation and business of operators in the EoL chain, as long as such transboundary shipments are legal. As long as such operators are certified according to a standard on the list by a reliable CA system, an adequate quality level of treatment can be ensured. For EoL operators, it is easier to fulfil their downstream due diligence obligations if they can select downstream operators with a reliable certificate documenting the downstream operator's compliance with a high quality standard from the list.

The qualification criteria for the acceptance of EoL standards and CA systems on the list of qualified standards should be worked out involving the stakeholders that have set up standards. Commercial actors such as producers and their take-back systems, public waste management authorities, independent organizations such as universities and other research bodies and NGOs should cooperate to ensure a good balance of commercial, technological, scientific and environmental aspects.

7.2 Adaptation and Improvement of Qualified Standards and Certification Systems

Once an EoL standard and its conformity assessment system has met the defined qualification criteria, it should be implemented without being stalled by burdensome debates between stakeholders over further evaluation criteria to achieve an equivalency ranking or other quality hierarchy of the qualified standards and CA systems on the list. Given the unsatisfactory state of current e-waste management and monitoring, any standard that qualifies for the adoption to the qualified standard list stands to improve the situation. Rather than losing time over discussions on the best standard, the quick application of qualified standards should have priority. Even a perfect standard and certification system is useless if it is not applied.

The standards on the list of qualified standards can only be a first step in a dynamic process, not a final result. The qualification criteria for the acceptance of EoL standards and their CA systems on the list of qualified standards should be revised and upgraded periodically. The revision should take into account the scientific and technological progress as well as the experiences of the various stakeholders collected during the practical application of the qualified standards.

Once the qualification criteria are revised, stakeholders responsible for the qualified standards and certification systems on the list should be given an adequate transition period to amend them in order to meet the revised qualification criteria. If they fail to amend the standards and CA systems, the respective EoL standard will be disqualified and be taken off the list. It is recommended that reviews of the qualification criteria and the qualified standards are conducted every four or five years to balance the needs of adaptation on the one hand and the expense for revising and newly implementing EoL standards on the other hand.

7.3 International Harmonization of EoL Standards and Their Certification

An international, high quality and effective standard for the collection, storage, transport and treatment of e-waste and for reliable certification so far is not available and may be difficult to achieve. Such a standard would have to be compatible with widely different legal, technical, economic and political framework conditions. The international scope might compromise the preciseness and enforceability of the stipulations, resulting in provisions that are too general to be effective. Such general provisions would allow EoL operators to continue to avoid compliance.

A first step overcoming these challenges is the definition of qualification criteria for qualified EoL standards and their certification systems, as explained above. In a second step, the stakeholders who worked out the qualification criteria for EoL standards and CA systems could submit these qualification criteria to an international standardization organization to further develop them into an international framework standard. This international framework standard could then become the basis to qualify EoL standards. This framework standard should be revised every four to five years to keep it up to date with the scientific and technological development. The framework standard should be strict enough to avoid loopholes in the EoL standards derived from it, but leave freedom to accommodate the legal and other differences between regions and countries in EoL standards and related CA systems. This could spur international cooperation and fair competition in high performance collection, transport, storage and treatment of e-waste.

8 Bibliography

BAN	Jim Puckett, Basel Action Network (BAN) et al.: Exporting Harm - The High-Tech Trashing of Asia; The Basel Action Network (BAN), Silicon Valley Toxics Coalition (SVTC) 2002; http://ban.org/E-waste/technotrashfinalcomp.pdf; last accessed 18 February 2012
Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; download from http://www.basel.int/text/documents.html; last accessed 27 February 2012
Basel Convention	Secretariat of the Basel Convention: Where are WEee in Africa?; Secretariat of the Basel Convention, December 2011; http://www.ewasteguide.info/files/Where%20are%20WEEE%20in%20Africa%20FINAL.pdf, last accessed 18 February 2012
Buchert	Buchert, Matthias et al., Ökoinstitut: Critical Metals for Future Sustainable Technologies and their Recycling Potential; United Nations Environmental Program 2009; http://www.unep.fr/shared/publications/pdf/DTIx1202xPA-Critical%20Metals%20and%20their%20Recycling%20Potential.pdf; last accessed 27 February 2012
Buenemann	Agnes Bünemann, cyclos GmbH, et al.: Planspiel zur Fortentwicklung der Verpackungsverordnung Teilvorhaben 1: Bestimmung der Idealzusammensetzung der Wertstofftonne; Umweltbundesamt Germany, February 2011, http://www.umweltdaten.de/publikationen/fpdf-l/4074.pdf; last accessed 31 March 2012
Chancerel	Chancerel, Perrine: Substance flow analysis of the recycling of small waste electrical and electronic equipment - an assessment of the recovery of gold and palladium;PHD thesis, TU Berlin, download from http://www.user.tu-berlin.de/perrine.chancerel/Dissertation_PChancerel_2010.pdf; last accessed 3 May 2010
China National Standard	National Standard for Environmental Protection of the People’s Republic of China, Technical Specifications of Pollution Control for Processing Waste Electrical and Electronic Products
Deubzer	Deubzer, Otmar: Explorative Study into the Sustainable Use and Substitution of Soldering Metals in Electronics - Ecological and Economical Consequences of the Ban of Lead in Electronics and Lessons to Be Learned for the Future; PhD thesis TU Delft, ISBN 978-90-5155-031-3, Delft, The Netherlands, January 2007
Deubzer	Deubzer, Otmar: E-waste Management in Germany, report from 20 July 2011 commissioned by the "Deutsche Gesellschaft für Interna-

	tionale Zusammenarbeit" (GIZ) GmbH, published by United Nations University; available from http://isp.unu.edu/publications/scycle/files/ewaste-management-in-germany.pdf; accessed 8 May 2012
E-Cycles	Department of Environmental Quality, Oregon, USA: Oregon E-Cycles Environmental Management Practices; download from http://www.deq.state.or.us/lq/pubs/docs/ORECyclesEnvironmentalManagementPractices.pdf; ; Oregon E-Cycles Collection System Standards, http://www.deq.state.or.us/lq/pubs/docs/ORECyclesCollectionSystemStandards.pdf; accessed 29 February 2012
e-Stewards	Basel Action Network (BAN): e-Stewards Standard for the Responsible Reuse and Recycling of Electronic Equipment, http://e-stewards.org/certification-overview/program-details/; accessed 22 February 2012
Ecoped Standard	Ecoped Technical Standard TÜV IT 003 MS, Service Certification Requirements For The Control Process For Mixed Weee Stream (R4) Collection, Transportation And Treatment, 2010, www.eco-guard.it, accessed 29 February 2012
Espejo	David Espejo: Assessment of the Flow and Driving Forces of Used Electrical and Electronic Equipment from Germany to Nigeria; master thesis BTU Cottbus, supervised by Dr. Otmar Deubzer and Dr. Jörg Becker, BTU Cottbus, in cooperation with and supported by United Nations University; BTU Cottbus 2011; http://isp.unu.edu/publications/scycle/files/master-thesis-david-espejo.pdf, accessed 2 February 2012
ErP Directive	European Union Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:EN:PDF; last accessed 27 February 2012
Gensch	Gensch, C. et al., Ökoinstitut; Deubzer, O., Fraunhofer IZM: Adaptation to scientific and technical progress under Directive 2002/95/EC, final report, 19 February 2009, Freiburg, page 265; http://ec.europa.eu/environment/waste/weee/pdf/report_2009.pdf; last accessed 19 August 2010
Huisman	Huisman, Jaco: The QWERTY/EE concept - Quantifying Recyclability and Eco-Efficiency for End-of-Life Treatment of Consumer Electronic Products; PhD thesis, TU Delft, ISBN 9051550170
Huisman	Huisman, J., Luepschen, C., Wang, F.: E-waste – How to address the size of the problem? Proceedings of the Care Innovation 2010 Conference, Vienna, Austria, November 2010

IEA	International Energy Agency (IEA): Transport Energy Efficiency, IEA Energy Efficiency Series, September 2010, available from http://www.iea.org/papers/2010/transport_energy_efficiency.pdf (accessed 5 February 2012)
ISO	ISO 14040, ISO 14044, ISO 14047 - ISO 14049, Environmental Management: Life Cycle Assessment (LCA) ; www.iso.org
ISO/CD	ISO/CD 14045 Environmental Management: Eco-efficiency assessment of product systems - Principles, requirements and guidelines; www.iso.org
ISO	ISO 14046 Environmental Management: Principles and guidelines for water footprinting of products, processes and organizations; www.iso.org
ISO	ISO 14067 Environmental Management: Carbon Footprint of products; www.iso.org
ISO	ISO 14069, Quantification and reporting of GHG emissions for organizations; www.iso.org
ISO	ISO 17000 Conformity Assessment: Vocabulary and General Principles; www.iso.org
ISO	ISO 17020 Conformity Assessment: General criteria for the operation of various types of bodies performing inspection; www.iso.org
ISO	ISO 17021 Conformity Assessment: Requirements for bodies providing audit and certification of management systems; www.iso.org
NIST	United States National Institute of Standards and Technology (NIST): Guidelines for Media Sanitization, NIST special publication 800-88, September 2006; available from http://csrc.nist.gov/publications/nistpubs/800-88/NISTSP800-88_rev1.pdf (accessed 8 May 2012)
OECD	Organisation for Economic Co-operation and Development (OECD): Guidance Manual for the Implementation of the OECD Recommendation C(2004)100 on Environmentally Sound Management (ESM) of Waste
PACE	Partnership for Action on Computing Equipment (PACE): Environmentally Sound Management (ESM) Criteria Recommendations, March 2009, http://archive.basel.int/industry/compartnership/docdevpart/aipgReportESMCriteriaRecommendationsn-2011-03-15.pdf; last accessed 27 February 2012
Parmenter	Parmenter, David: *Key Performance Indicators*; John Wiley & Sons 2010, ISBN-10: 0-470-54515-1, ISBN-13: 978-0-470-54515-7

R2	Responsible Recycling ("R2") Practices For Use in Accredited Certification Programs for Electronics Recyclers, http://www.r2solutions.org/index.php?submenu=Practices&submenu=Practices&src=gendocs&ref=R2Practices1&category=R2Practices; last accessed 29 February 2012
SENS	Technische Kontrollstellen SENS und SWICO: PCB in Kleinkondensatoren aus Elektro- und Elektronikaltgeräten; Schlussbericht September 2008, available from http://www.sens.ch/global/pdf/marktplatz/080919_PCB_in_Kondensatoren_d.pdf (accessed 6 February 2012)
Sepulveda	Sepulveda et al.: A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: Examples from China and India; http://www.ewasteguide.info/Sepulveda_2010_EIAR; last access 18 February 2012
StEP	Initiative White Paper "One Global Understanding of Re-Use — Common Definitions", 5 March 2009, http://www.step-initiative.org/pdf/white-papers/StEP_TF3_WPCommonDefinitions.pdf; last access 20 February 2012
UNEP	UNEP, StEP Initiative: From E-Waste to Resources; Report for UNEP, July 2009, download from http://www.ewasteguide.info/UNEP_2009_eW2R; last access 7 June 2010
UNU	Huisman, Jaco, United Nations University, et al.: 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), Final Report, download from http://ec.europa.eu/environment/waste/weee/pdf/final_rep_unu.pdf; last accessed 20 February 2012
Waste Directive	Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste (Waste Framework Directive); http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008L0098:EN:NOT; last accessed 7 February 2012
WEEE Directive	Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on Waste Electrical and Electronic Equipment (WEEE Directive)
WEEE Directive	Draft Recast WEEE Directive, http://www.europarl.europa.eu/sides/getDoc.do?type=TA&language=EN&reference=P7-TA-2012-0009#BKMD-9; last accessed 20 February 2012
WEEELABEX	WEEELABEX standards for collection, transport and treatment of e-waste, http://www.weee-forum.org/weeelabexproject, last accessed 29 February 2012

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Green Paper #3	TF 1 “Policy”	International policy response towards potential supply and demand distortions of scarce metals	01 February 2012
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White Paper #3	TF 1 “Policy”	On the Revision of EU’s WEEE Directive - COM(2008)810 final	1 October 2009, revised 22 March 2010
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About the StEP Initiative:

"StEP envisions a future in which societies have reduced to a sustainable level the e-waste-related burden on the ecosystem that results from the design, production, use and disposal of electrical and electronic equipment. These societies make prudent use of lifetime extension strategies in which products and components – and the resources contained in them – become raw materials for new products."

Our name is our programme: solving the e-waste problem is the focus of our attention. Our declared aim is to plan, initiate and facilitate the sustainable reduction and handling of e-waste at political, social, economic and ecological levels.

Our prime objectives are:

- Optimizing the life cycle of electric and electronic equipment by
  - improving supply chains
  - closing material loops
  - reducing contamination
- Increasing utilization of resources and re-use of equipment
- Exercising concern about disparities such as the digital divide between industrializing and industrialized countries
- Increasing public, scientific and business knowledge
- Developing clear policy recommendations

As a science-based initiative founded by various UN organizations we create and foster partnerships between companies, governmental and non-governmental organizations and academic institutions.

StEP is open to companies, governmental organizations, academic institutions, NGOs and NPOs and international organizations which commit to proactive and constructive participation in the work of StEP by signing StEP's Memorandum of Understanding (MoU). StEP members are expected to contribute monetarily and in kind to the existence and development of the Initiative.

StEP's core principles:

1. StEP's work is founded on scientific assessments and incorporates a comprehensive view of the social, environmental and economic aspects of e-waste.
2. StEP conducts research on the entire life cycle of electronic and electrical equipment and their corresponding global supply, process and material flows.
3. StEP's research and pilot projects are meant to contribute to the solution of e-waste problems.
4. StEP condemns all illegal activities related to e-waste including illegal shipments and re-use/ recycling practices that are harmful to the environment and human health.
5. StEP seeks to foster safe and eco/energy-efficient re-use and recycling practices around the globe in a socially responsible manner.

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