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Solving the E-Waste Problem (Step) White Paper

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

solving the e-waste problem

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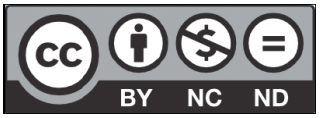

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Step White Paper Series

The Purpose of a Step White Paper is to state and explain Step's position on e-waste related issues, to make scientific-based recommendations and to provide guidance to relevant stakeholders and decision makers. Because all Step members endorse the conclusions made, all White Papers reflect a common Step standpoint.

Nevertheless, this White Paper is not an official document developed or endorsed by the Secretariat of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.

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- Schluep, Mathias (EMPA)
- Schroeder, Gideon (Cisco)
- Van Kerckhoven, Thierry (Umicore)
- Whiting, Patricia (US-EPA)
- Zanen, Jan (Chiho Tiande)

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Acronyms

CA	Conformity assessment
CFL	Compact fluorescent bulb
CRT	Cathode ray tube
DfE	Design for environment
DfEoL	Design for end-of-life
DfR	Design for recycling
EEE	Electrical and electronic equipment
EoL	End-of-life
ISO	International Standards Organization
LCD	Liquid crystal display
OHSAS	Occupational Health and Safety Assessment Series

PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
Step	Solving the E-waste Problem Initiative

Definitions

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 (OECD n.d.).
Certification	Issue of a third-party statement that fulfillment of the requirements of a standard has been demonstrated related to products, processes, systems or persons (ISO 17000).
Collection	The gathering of waste, including the preliminary sorting and preliminary storage of waste, for the purposes of transport to a waste treatment facility.
Cold cathode fluorescent lamp	Lamp used as backlights in flat panel displays; contains mercury (Step, 2012).
Conformity assessment	Demonstration that the requirements of a standard relating to a product, process, system, person or body are fulfilled (ISO 17000).
Disposal	Any collection, sorting, transport and treatment of waste as well as its storage and tipping above or underground which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy.
Effectiveness	Considers how successful a program is with respect to preventing pollution and recovering the environmental or economic value contained in e-waste (Huisman 2003).
Efficiency	Considers the trade-offs between the environmental benefits and impacts of an EoL operation (Huisman, 2003).
EEE	Electrical and electronic equipment. Equipment that is dependent on electric currents or electromagnetic fields in order to work properly and equip-

	ment for the generation, transfer and measurement of such currents and fields.
Electronic waste (E-waste)	A term used to cover items of all types of electrical and electronic equipment (EEE) that have been discarded.[1]
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.
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
Final disposal	Any operation with long term, final storage of waste where any recycling, reuse, refurbishment, or recovery options have been exhausted or are no longer viable.
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 q 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
Prevention	Measures aimed at reducing the quantity and the harmfulness to the environment of e-waste and materials and substances contained therein.
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 2012).
Recycling	Reprocessing waste materials for their original purpose or for other purposes. This excludes energy recovery, which is when combustible waste material is used as a means of generating energy through direct incineration, with or without other types of waste, and with heat recovery from the incineration process.

[1] This definition of e-waste was developed by members of the Policy Task force of Step for use by members in official Step publications. The definition document will be published first quarter 2014. Step members recognize that e-waste may have different definitions depending on the context or situation in which it the term is used.

Refurbish	Recovery, reclamation and repair of discarded or used electronic devices or components with the intention of resale or reuse.
Reuse	Any operation by which e-waste or components thereof are used for the same purpose for which they were conceived, including the continued use of the equipment or components thereof which are returned to collection points, distributors, recyclers or manufacturers.
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).
Separate collection	Collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment.
Standard	Formalized set of harmonized, consistent and acknowledged or established requirements applied to manufacturing processes, products, services and procedures (ISO 17000).
Storage	The presence of a quantity of dangerous substances for the purposes of warehousing, depositing in safe custody or keeping in stock.
Treatment	Any activity that occurs after the e-waste has been handed over to a facility for depollution, disassembly, shredding, recovery or preparation for disposal and any other operation carried out for the recovery and/or the disposal of the e-waste.
Waste	Any substance or object which the holder disposes of, or is required to dispose of, pursuant to the provisions of national law in force.

Executive Summary

Introduction and Objectives

As the sales of electronic and electrical devices increase, so does the amount of e-waste that needs to be handled as devices break, become obsolete or are no longer useful to their current owner. E-waste brings with it a host of issues, ranging from low collection rates to improper treatment and disposal, to lack of downstream transparency (Nixon et al. 2009, GAO 2005, IAER 2006, Saphores et al. 2006, Saphores, Ogunseitan, & Shapiro 2012). Improperly handled devices can lead to the loss of resources, worker and community exposure to hazardous materials and toxic chemicals, as well as environmental damage by wastes and other emissions that can occur during material recovery. This last issue becomes more damaging in developing countries where there is little to no protection for workers, communities or the environment. The purpose of this Solving the E-waste (Step) Initiative White Paper is to provide the Step Initiative's recommendations for a comprehensive approach to responsible e-waste management to be included in a standard or set of standards aimed the responsible collection, handling, treatment and disposal of electrical and electronic equipment at the end of their useful life.

Scope and Boundaries

Recycling standards, as outlined in this paper, should maximize the quantity, quality and value of recycled materials and minimize or eliminate the impacts of processes and materials on human health and the environment. Reuse and refurbishment are key steps at the beginning of the processes covered by these standards, and they are considered in this context in this document. While the recommendations presented here would apply to standards for reuse and refurbishment programs, they do not provide specific information regarding standard development for these systems.

To enable the development of standards, two sets of recommendations are provided: (1) common principles that form a foundation for all standards developed based on these guidelines, and (2) specific requirements focused on the different stages of e-waste management that can be included as appropriate for the scope of the standard under development. Also presented is an overview of existing standards and how they address the characteristics and practices necessary for a responsible program.

The primary target audience for this guidance includes individuals or organizations that would like to develop and implement standards around the collection, handling, transport, storage, and treatment of e-waste – either internal to their own organizations or external for assessing the operations of potential partners, or as part of a larger multi-stakeholder initiative. The guidance is also relevant for policy makers who would like to develop new policies or regulations to further encourage responsible e-waste management.

Elements of E-waste Management Standards

While the requirements of standards may vary depending on their intended audience, a shared set of principles can be used by all standards to provide a common understanding of the issues and approach to e-waste management, as well as a point from which harmonization across different standards may be possible.

Because of the variety and continual evolution of materials in e-waste and the processes required to recover them, the precautionary principle should be used. The precautionary principle states, "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (Rio 1992). Standards developers should assume that potential environmental and health impacts will be realized, and include requirements to mitigate or counter adverse effects.

Leading from the precautionary principle, the waste hierarchy provides a "rule of thumb" for prioritization of treatment options (EC 2008, USEPA 2013, Envirobiz Group 2010). The waste hierarchy consists of: 1) prevention of waste generation; 2) preparation for refurbishing and reuse; 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

The overall success of responsible e-waste management depends not only on the individual performance of the various end-of-life (EoL) operators and producers in the life cycle of electrical and electronic equipment, but also on their optimum co-operation and alignment. It is important for individuals or organizations to use a systems thinking approach when developing the scope of programs and responsibilities of the actors responsible for actions under the standard. This means that all aspects of e-waste collection, transport, handling and treatment need to be considered, as well as how a program is managed, measured, reviewed and audited. A standard developer should clearly define:

- *Program scope*, or what the standard considers e-waste, what products are included under the standard and to which portions of the end-of-life phase of the product life cycle it applies;
- *Operational responsibilities*, or who is affected by the standard and outline their responsibilities to help ensure the appropriate party meets them;
- *Program performance metrics and targets*, to outline the measurements and goals that enable a program to be assessed for compliance with the standard;
- A timetable for *periodic public review*, which allows a standard to adapt to the recent scientific findings, industry best practices and technological progress as they evolve over time; *and*
- *Auditability* of programs to the standard and guidelines for *conformity assessment through third-party audits* that enable a program to reliably demonstrate it complies with the requirements of a standard in daily operations.

General Program Requirements

Standards should be designed with common outcomes in mind as opposed to prescribing a method to manage or to treat e-waste. Focusing on outcomes or the results of a given set of requirements, rather than the specific process steps, enables organizations with diverse business models to move to a common goal and provide room for innovation around better and more effective approaches to responsible e-waste management. Because a broad array of standards already exists at local, national and international levels, it is incumbent upon the individual or organization developing a new standard to first ensure that an existing standard does not already meet their needs, and if not, how to harmonize their efforts with existing standards to minimize the management burden on their targeted audience.

Before considering specific requirements for the different stages of the EoL phase for electronic and electrical equipment, there are general program requirements all standards should incorporate. These are:

- *Legal Compliance:* all operators should comply with local, regional, national and international legislation and treaties as they apply to their operations. Proof of legal compliance is shown through: 1) records of all necessary permits, licenses and other legally required documentation from partners (e.g., loading and shipping confirma-

tions) and 2) proof of management systems that allow them to stay up-to-date with new or revised legal requirements.

- *Financial Liability and Insurance:* operators should have insurance in place to cover damages to third parties, including: environmental damages, health impacts to workers and the general public, damages to (including loss or theft of) properties, cyber-liability and the proper closure and cleanup of the operation site when necessary.
- *Documentation and Downstream Due Diligence:* Operators should document all flows of e-waste, components, fractions and materials both entering and exiting their facilities, as well as require such documentation from downstream partners. The standard should require of the operator downstream due diligence regarding the fate of all e-waste and derived material originating with their facilities.

  Operator responsibility for materials exists as long as the forwarded e-waste and any component or materials derived during treatment meet end-of-waste criteria (EC, 2008) or are finally disposed of. They shall document the fate of the e-waste, its components and materials to this stage. A clear statement regarding what information and reporting each participant is accountable for should be included in the standard. While an operator may not physically handle material to this point, they are responsible for selecting downstream partners that meet and can document their compliance with the standard.
- *Environmental, Health and Safety Management System (EHSMS):* Standards should require operators to demonstrate implementation of EHSMS systems in accordance with international standards. Staff should be adequately trained and qualified for the proper operation of the facilities and use of personal protective equipment appropriate to staff responsibilities. Training should occur regularly, and operators should maintain records that include employees' responsibilities, training schedules and records showing completed education and training for each employee.
- *Labour Rights:* Maintaining reasonable safeguards and healthy working conditions for workers is a crucial responsibility for a program operator, and this should be reflected in standards development. EoL standards should require fair payment, appropriate social and workplace conditions and the absence of discrimination towards workers. Consideration of worker long-term health should also be considered by providing requirements around health tests. Standards set by the International Labour Organization can provide further guidance during EoL standard development (ILO, 2014).
- *Hazardous Materials:* From the point of collection to final disposal, there is a potential risk to the environment and human health due to the hazardous materials contained in e-waste. As pollution prevention is a primary focus for e-waste management, standards must clearly define what constitutes hazardous materials and components that are to be removed and handled separately. The standard should also require that, once removed, these materials are responsibly handled through separate material recovery and disposal streams appropriate to the material in question.

Specific Program Requirements

In addition to the general considerations above, an EoL standard developed under these recommendations should consider the unique aspects of each stage of e-waste handling, from the point where the final owner has no further use for the product.

- *Collection:* Collection of e-waste should be done separately from other types of waste, in facilities within a reasonable proximity of consumers, and services should be well communicated or advertised to maximize collections. Additionally, a standard may stipulate the number of collection sites per region or population density, whether the products are separated by type or category prior to further treatment and handled in such a way that does not damage the device or hamper reuse, refurbishment or proper recovery.

- *Transport and Storage:* EoL standards should ensure that e-waste is packaged, stored and transported in such a way that it is undamaged in order to minimize the potential for pollution from the hazardous materials described above, enable full reuse or refurbishment to occur and bring the standard in line with the top levels of the waste hierarchy. Storage sites must be equipped to prevent pollution and other hazards due to damage, leakage and corrosion, or from inflammable and explosive components. Standards should stipulate these conditions with clear and product-specific stipulations on how to handle e-waste during transportation and storage.

  Special consideration should be given to the transboundary movement of e-waste due to the wide variety of legal requirements and conditions that exist globally. At an international level, the Basel Convention (Basel Convention, 1989) is the most comprehensive framework agreement on transboundary movements of wastes. Therefore, EoL standards should 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. Beyond adherence to the Basel Convention, a standard should stipulate that the most rigorous protocols be employed for transboundary shipments, which will allow all shipments to operate within the legal boundaries of any importing and exporting country at all times.

- *Treatment:* If not conducted at collection, e-waste should be assessed for potential reuse and refurbishment rather than entering the waste stream. Reuse saves energy and resources that would be required for new products and enables the adoption of technology by those with low incomes, but the process may face challenges with limited markets for secondhand goods and poor energy efficiency compared to newer models.

  Following the waste hierarchy, e-waste should next enter into a recycling stage, where an EoL standard should stipulate quality recycling requirements based on what can be achieved with best available technology, but without prescription regarding the technology to be used. EoL standards should incorporate the waste hierarchy, requiring that material or fractions move to incineration and final disposal only once all reuse, refurbishment and material recycling options have been exhausted. Often, incineration or disposal to landfills is less expensive, which generates incentives to

choose this disposal route. A standard must be clear that this is acceptable only after all other options have been exhausted. Standards should also require operators to use final 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.

1 Introduction

1.1 Objective

Over the last decade, consumer electronic sales have risen significantly in the U.S, Europe, and Asia (USEPA 2008, Bhutta 2011, Oguchi 2008, Watts 2009), and are they anticipated to accelerate. A related trend to the rapid rise in sales of electrical and electronic equipment (EEE) is a rapid rise in the generation of e-waste over time. Issues with e-waste have been well documented, ranging from low collection rates to improper treatment and disposal and lack of infrastructure to lack of downstream transparency (Nixon et al. 2009, GAO 2005, IAER 2006, Saphores et al. 2006, Saphores, Ogunseitan, & Shapiro 2012). Low collection rates and ineffective material recovery result in lost resources when precious metals and other raw materials are not efficiently captured. Handling and treatment of e-waste can expose workers to hazardous materials and toxic chemicals during recovery. This situation is exacerbated by the amount of e-waste processed in developing countries where there is little to no protection for workers or the environment (Widmer 2005, Williams 2008, Amoyaw-Osei 2011). Recently, the "2013 Geneva Declaration on E-Waste and Children's Health" was published to raise awareness of human health risks by exposures to e-waste (Geneva Declaration 2013). Due to the broad scope and inherent global nature of these issues, solutions are challenging to find.

A set of standards that clearly define how e-waste should be handled from the point of collection to final disposal is one aspect of addressing the issues related to e-waste. The goal of this White Paper is to present the recommendations of the Solving the E-waste Problem (Step) Initiative on what characteristics and practices a comprehensive program should include to ensure that e-waste is collected, handled and treated responsibly, with minimal impact to the environment and communities and maximum recovery of valuable resources. Reuse and refurbishment are key steps at the beginning of the processes covered by these standards, and they are considered in this context in this document. While the recommendations presented here would apply to standards for reuse and refurbishment programs, they do not provide specific information regarding standard development for these systems.

The recommendations presented represent the issues an interested party should account for when designing a standard to address one or more stages of the end-of-life (EoL) phase. This document is not intended to be used as a standard itself, but as a set of guidelines for standard-setting organizations.

The precursor to this work, "Recommendations on Standards for Collection, Storage, Transport and Treatment of E-waste", published by Step in July 2012, provides greater detail on the issues, best practices and potential implementation routes for solutions that extend beyond the current standards space.

1.2 Target Audience

The target audience for this work includes individuals or organizations that plan to develop and implement e-waste collection, handling and treatment standards either internally to their own operations, or externally for assessing operations of potential partners either individually or as part of a larger initiative (standard setting or regulatory). This White Paper should also inform policy makers who are involved in developing new policies or standards, or are responsible for evaluating existing programs within a governmental context.

2 Summary of Existing Standards and Regulations

2.1 Standards versus Regulations

Both standards and regulations provide a path for enabling an organization to manage e-waste in a responsible manner. Regulations are a set of requirements that have become law and are enforced through government auditing and action. Instead of creating new requirements, regulations may reference or incorporate existing standards, providing more credibility and weight to the standard through its use in a legally binding context.

A standard is a "formalized set of harmonized, consistent and acknowledged or established requirements applied to manufacturing processes, products, services and procedures" (ISO 17000). Standards are not legally binding unless they are incorporated into law or cited in a regulation, although the standard operator may require a contractual agreement with organizations desiring certification against their standard. Standards may be internal to an organization and developed to assess their own operations, or external, where multiple organizations come together to develop a common understanding and set of requirements around e-waste management. Particularly effective or comprehensive standards may initially be designed for a single organization, but they may become acknowledged and established in a market by repeated and common use. Requirements may also be drafted by a non-governmental organization that may also certify organizations to the standard.

Standards should be designed with common outcomes in mind, as opposed to prescribing a method to manage or to treat e-waste. Focusing on outcomes or the results of a given set of requirements, rather than the specific process steps, enables organizations with diverse business models to move to a common goal and provide room for innovation around better and more effective approaches to responsible e-waste management. Further, the process of managing e-waste needs to be certified at a facility level, rather than for an organization or company as a whole. The standards should focus on activities that occur at the facility level, and each facility should be assessed for its performance against a chosen standard. This point is of particular importance when one organization operates multiple facilities. Facility-level focus ensures the actual collection and treatment of e-waste occurs in accordance with the standard and helps identify and minimize variations across multiple locations to enable responsible treatment regardless of location. Additionally, because they are voluntary, standards need a strong audit function incorporated into the program to ensure that all requirements of the standard are being met.

2.2 Overview of Existing Programs

Global initiatives have already been enacted at both the voluntary standard and regulatory levels in recognition of the importance in the responsible management of e-waste. Annex A provides an overview of existing standards and regulations worldwide and assesses which recommendations presented in this document they cover.

Even with the clear desire for better global management of e-waste, a single internationally-recognized standard does not exist. The variety in scope and requirements of regulations presented in Annex A illustrates the challenge recyclers, producers, retailers and other organizations face when trying to implement e-waste management systems. When e-waste management programs must also comply with a variety of e-waste standards, it further increases the overall compliance burden.

The ideal approach to mitigate this situation is to create a single internationally-recognized standard or a single harmonized approach where all standards require a similar set of outcomes. Until this exists,

however, new and existing standards should establish routes for mutual recognition (i.e., one standard recognizes certification to a different standard as equivalent to certification to their standard). Additionally, when new standards are developed, those responsible should first determine if an existing standard meets their needs and if not, determine where they can harmonize with existing standards to minimize the burden of program assessment on their target audience.

One aspect of e-waste handling not extensively covered in existing standards is the collection, handling and transport of e-waste material before it enters the treatment phase. Existing standards focus on handling, transport and treatment of e-waste once it has been received and is passed to reuse or prepared for refurbishment or materials recovery through recycling and other activities. Collection, handling and transport issues are rarely covered due to the wide variety of approaches and activities that may be involved in receiving used products from the residential, commercial and institutional electronics users. Two examples of standards that address collection and transport are the WEELABEX Collection Standard and the "Comprehensive Program for the Proper Handling of Covered Electronic Devices" in the state of West Virginia, USA, which define best practices that those programs engaging in collection of EEE can reference to ensure they are also responsibly handling the materials in their possession (WEELABEX 2011, WV 2011).

3 Common Elements of E-waste Management Standards

3.1 Introduction

Regardless of whether a standard is intended to be used internally by an organization or is the result of a large multi-stakeholder effort, all programs developed with the intent of managing e-waste should contain a common set of elements that serve as a foundation for the management requirements. This section outlines the recommended elements all standards should incorporate.

3.2 Precautionary Principle

The precautionary principle states "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (Rio 1992). Because of the rapid rate of technology change, which in turn directly affects the rate at which the new materials and products reach the EoL stage, there be insufficient scientific evidence and experience to understand the impact on the environment, health and safety when these products are recycled. Application of the precautionary principle to e-waste means that if there are substantiated suspicions of adverse impacts to health and environment as a result of handling and treating a certain waste device, any EoL standard should assume that these impacts will be realized and include requirements to mitigate or counter adverse impacts.

3.3 Scope and Responsibilities

Scope

Clear definition of what products or processes are in scope is necessary for effective implementation of any standard. For EoL standards, this is more challenging as a single accepted definition of "e-waste", or the materials that term encompasses, does not exist. Each EoL standard must clearly define what it considers e-waste, what products are included under the standard and to what portions of the EoL phase it applies. One example for broad EEE categorization is Annex I of the

WEEE Directive in the European Union (WEEE 2012), where 10 categories of products are defined to describe what EEE are considered as "e-waste under the directive".

Waste Hierarchy

The overall goal of any EEE EoL management program is to maximize the useful life of products through reuse and refurbishment and then recover materials from the products before moving material to energy recovery or final disposal (European Commission 2010, USEPA 2013, Environbiz Group 2010).
To minimize the environmental impacts of waste, the following waste hierarchy should be applied:

1. Prevention of waste generation
2. Preparation of materials or products for refurbishing and reuse
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 in landfill sites

EoL standards should stipulate this hierarchy in their provisions as a "rule of thumb" for prioritization of treatment options.

Operational Responsibility

Because of the wide variety of parties engaged in the collection, handling, storage, treatment and disposal of e-waste, an EoL standard must define who is affected and outline their responsibilities. Each party has a unique role with associated responsibilities, and clearly laying out these responsibilities helps ensure the appropriate party meets them. These associated responsibilities are also highlighted throughout Section 4, where the general requirements a standard should incorporate are laid out.

3.4 Systems Thinking Approach

Coverage

For effective e-waste management, EoL standards should take into account the full range of activities in the EoL supply chain. Reuse and environmentally responsible recycling are key activities, but they can be rendered ineffective by improper collection, handling, storage or transport of e-waste, which results in broken or damaged equipment. Additionally, equipment sold to brokers who engage in the movement of the material outside of responsible treatment schemes, illegal transboundary shipments or illegal material dumping can further undercut efforts to mitigate the environmental, health and safety impacts from e-waste.
To ensure that programs are comprehensive relative to the entire EoL supply chain, EoL standards should include requirements for collection, handling, storage, transport, treatment and disposal of all materials. If all aspects are included, and included in compliance audits, a program has a higher level of certainty that all material is managed in accordance with the EoL standard.
An additional aspect to consider is the influence design has on the EoL performance of EEE. Design for EoL (DfEoL) is one aspect of the broader considerations under Design for Environment (DfE), the goal of which is to optimize the overall environmental performance of a product. However, trade-offs between different design elements needs to be considered carefully. While EEE designed to be disassembled easily or to exclude certain materials could improve the environmental performance of a product at EoL, it may shift the burden to another part of the product life cycle. An example of this type of burden shift occurred when lead was banned from EEE. The identified alternatives for lead required increased energy consumption to produce and use of scarce resources to produce the same functionality (Deubzer

2007). Because EoL standards are narrow in scope by nature, product design requirements should be addressed in life cycle-oriented regulations, standards and guidelines such as the Energy-related Products Ecodesign Directive from the European Union (ErP 2009).

Metrics and Targets for Program Performance

Accordance with the Waste Hierarchy outlined in section 3.3.2 leads to, among other benefits, pollution prevention and resource conservation. To assess these benefits, the operator of a standard should require an organization certified under their standard to report against metrics or to meet targets set around e-waste management as part of the standard. One approach is to consider performance indicators that assess the status of environmental hotspots within an organization's operations and how the organization improves over time (Parmenter 2010). Environmental screening tools and indicators such as carbon footprints (e.g., see ISO 14064, ISO 14069) and water footprints (e.g., see WFN 2014) may be used to evaluate a certified organization's specific environmental impacts and their changes over time as well. These types of 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.

To consider the broader impact of an e-waste management program, measures of effectiveness and efficiency may be included. Effectiveness considers how successful a program is with respect to pollution prevention and recovering the environmental or economic value contained in e-waste (Huisman 2003). Efficiency considers the trade-offs between the environmental benefits and impacts of an EoL operation (Huisman 2003). An in-depth discussion of one approach to handling these measures can be found in the Green Paper, "Recommendations on Standards for Collection, Storage, Transport and Treatment of E-waste" (Step 2012).

A standard may also set targets to ensure that an organization is reaching a minimum performance threshold. Standards for the collection of e-waste may set quantitative collection targets in order to achieve a certain minimum amount of collection, particularly in the absence of legislative requirements. Recycling targets would set a minimum quantitative threshold for the amount of materials to be recycled from treated e-waste. Caution, however, is needed to not overlook critical, harmful materials used in small quantities when setting specific mass targets for overall recovery and recycling EEE. Approaches to calculating and setting these targets in line with the program recommendations outlined in this document may also be found in the original Green Paper (Step 2012).

Requirement Setting and Periodic Review

Meeting the requirements laid out in either voluntary standards or government regulations usually requires effort on the part of organizations wishing or required to report. Therefore, it is important for the EoL standard to take into account the entire EoL phase by including all operators instead of focusing on one part of the EoL chain. In particular, the standard developer should consider that:

- Each requirement should help improve the performance of the EoL operators in a specific stage of the e-waste management, such as collection, transport or treatment.
- The requirements should also maximize, or at least maintain, the environmental and economic performance of other operators in the entire EoL chain.
- The requirements are set only where markets or existing regulations do not drive EoL operators to achieve desired levels of environmental, health and safety performance.

EoL standards should include a timetable for periodic public review. This allows for the standard to adapt to the most recent scientific findings and technological progress, incorporate the best available technology and practices for e-waste management and integrate learning from the experience of implementing the standard. A stipulated review period also ensures that the standard is reviewed on a schedule relevant to the standard itself, rather than one subject to the interest and desires of the stakeholders responsible for standard development. A cycle of four to 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.

4 General Requirements

4.1 Introduction

Regardless of the scope of a standard under development, all standards should incorporate requirements that ensure a program operator is legally responsible, performing due diligence with respect to their downstream partners and material flows, and protecting the environment, workers and the communities in which they operate. This section provides recommendations on how a standard should consider these aspects of e-waste management programs.

4.2 Legal Compliance

All program operators should comply with local, regional, national and international legislation as they apply to their operations. Proof of legal compliance includes two requirements. The first is knowledge of applicable legislation and proof of compliance. As part of auditing requirements, operators should be able to show that they are informed about the legislative requirements as they apply to their location and operations. They must also keep records of all necessary legal permits, licenses and other legally required documentation from partners in the EoL waste stream, such as loading and shipping confirmations from downstream partners. The second requirement is the ability to track changes in legislation and to obtain information on new and upcoming legislation. Operators should demonstrate that they have implemented management structures to ensure that they stay up-to-date with legal requirements. This should include an approach of continuous monitoring and implementation of legal compliance.

4.3 Financial Liability and Insurance

Standards should require operators to have insurance in place to cover damages to third parties, including: environmental damages, impacts to the health of workers and the general public, damages to properties (including loss or theft), cyber-liability, and for the proper closure and cleanup of the operation site when necessary. Insurance covering second party risks should not be mandatory in an EoL standard.

4.4 Material Flows and Downstream Due Diligence

Ensuring that e-waste is handled responsibly and within a managed system through to final disposal is crucial to averting the social and environmental impacts related to irresponsible handling, treatment and disposal. Program operators are responsible for activities throughout the downstream supply chain, and a standard should require they perform due diligence and are accountable for all downstream flows of e-waste, including its final disposal. Due diligence includes, but is not limited to, ensuring that their downstream operators are in legal compliance, maintain proper handling and processing of e-waste, and com-

ply with other obligations such as those around labour rights and social improvement initiatives.

Material Flow Documentation

The EoL standard should specify that operators shall document their activities, including incoming and outgoing flows of collected e-waste and its components, fractions and materials, in order to monitor and maintain compliance with the standard. Proof of compliance should be documented through invoices, certificates and other confirmations as necessary. Operators should require documentation from downstream suppliers of the types and amounts of the downstream flows, as well as their fate, in order to comply with their downstream due diligence.

Downstream Due Diligence

EoL standards should require downstream due diligence regarding the fate of all e-waste and derived materials operators hand on downstream. They shall be accountable for it as long as the forwarded e-waste or derived materials are wastes or are finally disposed of, and they shall document their fate to this stage. An example definition of waste is provided in the WEEELABEX standard (WEEELABEX 2011). A clear statement regarding what information and reporting each participant is accountable for should be included in any standard. These standards should recognize that operators cannot delegate their responsibilities downstream, but they must maintain control over the flows of e-wastes and derivative components and materials. This includes the selection of downstream operators who:

- Work according to legal requirements.
- Have the technical, infrastructural and organizational structures in place to enable them to meet the standard and the targets upstream operators are required to meet regarding the proper handling of the e-waste and derivative components, fractions and materials that pass through their facilities.
- Comply with other requirements and targets of the EoL standard, such as those regarding labour and social issues as well as financial liability, which the EoL standard should clearly defines as being applicable to downstream operators.
- Have proof of compliance with the EoL standard requirements, including documentation for tracking inbound and outbound material flows and their downstream fate.
- Have the necessary equipment on site to measure and document e-waste material flows such as scales adapted to measure the specific materials moving inbound and outbound from their facilities. E-waste and its derivative components, fractions and materials coming in and going out should be weighed to facilitate the comprehensive monitoring of the mass flows along the EoL chain.

EoL standards should include the downstream due diligence and tracking of any flow of equipment or materials that is exported to another country. This accountability is required of all actors in the EoL supply chain and should comprise reasonably appropriate financial liabilities and insurance requirements. It must also be evidenced with adequate documentation that any facilitates handling materials for or from a particular organization undergo ongoing third-party assessments.

Many of the due diligence responsibilities may be met through permits, environmental legislation, certifications or auditing schemes. Regardless, which activities are and are not considered acceptable to fulfill these responsibilities should be clearly stated in the standard.

4.5 Environmental, Health and Safety Management Systems

Due to the potentially hazardous nature of e-waste, an environmental, health and safety management system (EHSMS) should be implemented and operated as part of a responsible e-waste management program. The EoL standard should require that the operators have an EHSMS in accordance with international standards such as OHSAS 18001 or ISO 14001 (OHSAS 18001, ISO 14001). Operators should be able to demonstrate that they comply with these additional standards. The EoL standard should also require that they have the necessary infrastructure in place to identify and assess their relevant environmental, health and safety risks, so that the certified operator can work to eliminate or continuously reduce the risks. The operator should also demonstrate that they have set targets and achieved improvements in the relevant areas during the time they have been operating under the EoL standard.

The standard should also specify that staff is adequately trained and qualified to manage proper operation of their facility and comply with the requirements and targets of the EoL standard. This must include access to, and training on, the use of personal protective equipment. All training programs should be executed on a regular basis (e.g., annual refresher training courses) and properly documented for future reference.

During assessments, operators must allow interviews with workers in a manner that ensures confidentiality and avoids future adverse consequences for participating employees. Measures of verification may include organizational charts with company structure. These documents should include employees' responsibilities, training schedules and records showing completed education and training for each employee.

4.6 International Labour Standards

Many e-waste standards center on the material itself – the products and materials recovered from those products, how they are handled as they move through the EoL phase and their eventual fate at final disposition. At each step in the e-waste management process, there are workers responsible for handling the products and derived components, fractions and materials. EoL standards must ensure the well-being of these workers, because when the economic pressure on an organization increases, workers' rights to fair and reasonable working conditions may be sacrificed before other aspects of operations. Not only does this erosion of worker considerations negatively impact the worker, but uneven implementation of labour standards results in an uneven playing field where operations that provide for their workers may be at an economic disadvantage to those who do not (ILO 2014).

Maintaining reasonable safeguards and healthy working conditions is a crucial responsibility for a program operator, and this should be reflected in standards development. EoL standards should require fair payment, appropriate social and workplace conditions, and the absence of discrimination towards workers. Consideration of worker long-term health should also be considered by including requirements for ongoing health monitoring. Operators should prove that their employment contracts comply with minimum legal occupational requirements. As requirements vary by location, international social and labour standards should serve as a guide to minimum requirements and targets within a standard. EoL standards may also include labour and worker health issues as part of the audits required to comply with the standard.

5 Collection, Transport and Storage

Once the owner of EEE determines they no longer have use for the equipment, the products move into the EoL phase, starting with collection. Collection, storage and transport of e-waste should be executed in a way that prevents damage to the environment and human health damages and ensures that methods are employed to maximize recycling. To enable reuse and effective treatment, standards should require operators to collect, store, handle and transport e-waste in a manner 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 reuse and recycling of e-waste, as well as the proper disposal or incineration of materials that cannot be treated otherwise.

To ensure that all of these requirements are met, adequate infrastructure should be in place to support responsible handling and systems or processes to monitor and supervise handling of e-waste at each step. Staff should be trained to handle incoming e-waste and the equipment and tools required to properly treat the materials at this stage. The following sections outline the measures that should be in place for each process.

5.1 Hazardous Materials

At every process step during collection, transport and storage of e-waste, there is a potential risk to the environment and human health due to the hazardous materials contained within e-waste. Examples of hazardous materials that can be found in e-waste are:

- LCD flat panel displays with mercury-containing CCFL (cold cathode fluorescent lamps) backlights.
- Compact fluorescent lamps (CFLs, or “energy saving lamps”) containing mercury.
- Capacitors containing polychlorinated biphenyls (SENS 2008).
- Older cooling and freezing equipment containing hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs) as cooling agents.
- Lead and cadmium in electronic and electrical components, as well as the brominated flame retardants polybrominated diphenyl esthers (PBDEs) and polybrominated biphenyls (PBBs) with a high dioxin and furan potential.
- Batteries.

EoL standards shall clearly define hazardous materials and components to be removed from e-waste. The standard should also specify clear provisions regarding the separate treatment of removed hazardous materials and components, and specifically outline how this is to be done by the initial handler upon collection of equipment.

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

5.2 Collection

The collection of e-waste should be done separately from other types of waste in order to provide adequate treatment, thus preventing pollution and loss of resources. E-waste collection facilities may co-locate

with collection facilities for other types of materials, as long as the e-waste is not mixed with other waste, and adequate space is available to safely and securely handle and store collected e-waste.

Site Organization and Management

Collections sites should be located within a reasonable proximity to consumers, and their services should be well communicated or advertised in order to maximize collection returns. To encourage adequate coverage of an area, an EoL standard may set a target distribution of collection sites. Examples of different types of targets are the number of containers available, a set number of drop-off locations per area determined by population density or that enough containers or facilities exist so that consumers only have to travel a maximum distance to reach one. The EoL standard may also specify that products be separated and stored by type to ensure each type of EEE is handled in the most responsible manner without damage or loss. If this requirement is included, the standard shall declare which categorization scheme the separation is based on.

Data Security

The reuse of information and communication technology (ICT) equipment presents data security concerns. Data on computers, mobile phones or any other piece of equipment with stored memory that was not securely removed by the previous owner has the potential to be accessed and abused after being discarded. EoL standards should therefore set requirements to ensure data security prior to reuse. Reference to standards and guidelines on data security measures such as NIST 800-88 (NIST 2006) or HMG Information Assurance Standard No. 5 may be useful.

5.3 Transport

General Considerations

A standard should ensure that e-waste is transported in a way that enables maximum reuse, recycling and resource recovery from e-waste and prevents pollution or contamination as previously mentioned. This means all EEE should be packaged so that damage is minimized during transport. In addition to preserving potential uses, appropriate packaging could prevent a hazardous material transportation incident, given the nature of the hazards contained in e-waste. In order to achieve this, several requirements should be included:

- When loading equipment on and off trucks or containers, operators should be properly trained to handle the materials in question and use the equipment provided for such activities. In particular, sufficient packaging, labelling and appropriate stacking of collected equipment is necessary.
- Transport vehicles and containers must be properly equipped to minimize damage to e-waste equipment. This prevents exposure of hazardous components during transport and minimizes further damage to potentially reusable e-waste.
- Special precautions should be taken when handling and transporting hazardous materials. Examples of such equipment are: LCD flat panels, Compact Fluorescent lamps and waste refrigerators containing HCFC, CFC and/or HFC.

Due to the long distances over which e-waste is often transported, efficient logistics operations are important for the environmental performance across the entire EoL supply chain. Standards that address the transport of e-waste should require operators to develop a logistics plan for minimizing the environmental impacts of transport.

Transboundary Shipment

E-waste is a global market, and transboundary shipment is often needed to reach an appropriate recycler or reuse markets. When defining a responsible e-waste program through an EoL standard, determining the requirements around transbouandry shipments is one of the most challenging and complex topics encountered. Legal requirements and conditions for transboundary movements of e-waste may differ from country to country for both importing and exporting countries. They also differ according to purposes for which material may be shipped (e.g., only for reuse, for recycling, incineration or for disposal). Also, significant differences may arise from the implementation and enforcement of the same legal requirements within a given region (e.g., wide disparities between EU Member States regarding enforcement of the Waste Shipment Regulation).

At an international level, the Basel Convention (Basel Convention 1989) is the most comprehensive framework agreement on transboundary movements of wastes. Therefore, EoL standards should 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. Beyond adherence to the Basel Convention, a standard should stipulate that the most rigorous protocols be employed for transboundary shipments, which will allow all shipments to operate within the legal boundaries of any importing and exporting country at all times.

Illegal transboundary shipments, wherein e-waste is illegally shipped across national borders, present a significant challenge to attempts to regulate and monitor e-waste. Effectively addressing illegal shipments of EoL products would not only help prevent environmental damage, health impacts and a loss of valuable resources related to improper handling and treatment of e-waste, but it would also result in direct economic benefits for both importing and exporting countries and ensure a level playing field between operators (e.g., see Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste).

Requirements for Legal Transboundary Shipments

EoL standards should stipulate measures to prove the legality of exports:

- EoL operators working under an EoL standard must hold all legally-required documents and permits for any transboundary shipment of e-waste as well as the components, fractions or materials thereof. These documents and permits must 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 and outgoing e-waste, reused equipment, components, fractions and materials from facilities directly under their control and maintain evidence of due diligence, tracking and documentation down the complete EoL chain to the final disposal of the incoming devices and materials.

EOL standards should also stipulate strict and clear requirements for transboundary shipments. These may exceed, but never undercut, the regulatory requirements for legal shipments. The standard should require the following conditions to be demonstrated by EOL operators as well as treatment facilities, including recycling facilities:

- 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 as well as effi-

ciency of the recovery process (range and yields of the materials recovered), similar to the country in which the e-waste arose,
-And-

- 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 similar to the country in which the e-waste originated.
-Or-
- 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. This needs to be certified by third-party.

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 may not be enough to justify the export of components, materials or fractions of e-waste if the other downstream conditions outlined above cannot be met. If wastes resulting from this treatment cannot be recycled, incinerated or disposed of properly according to the requirements of the EOL standard, the standard should exclude such exports as acceptable under its requirements.

The burden of proof remains with the operator initiating the export that the final destination of exported e-waste, components, fractions and materials originating in the exporting country or generated in the importing country is legal and appropriate for the material shipped. The exporting operator is also responsible for ensuring that facilities handling their material have been duly certified by third parties per the EoL standard.

However, provided these shipments are legal, EoL standards should 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 similar or lower health and safety risks as the country of origin.

Reuse and Illegal Exports of E-waste

E-waste is often labeled as equipment for reuse, even though it is not in a condition that allows for its reuse and should be considered waste. A major challenge is differentiating illegal exports of non-functioning equipment from used products actually intended for reuse.

Equipment exported for reuse must be sufficiently functional, and its transport and storage must ensure that this functionality is maintained during transport. In addition to the due diligence and record-keeping already discussed for e-waste, an EoL standard should include requirements to ensure the following for equipment shipped for reuse:

- Equipment destined for direct reuse is properly tested for functionality and shows evidence of functionality testing.
- Equipment is properly packaged, stored and transported (through both appropriate packaging and stacking) for reuse so that it maintains its functionality.
- The operator is able to provide invoices or sale contract from the person or body that purchased the equipment stating that the equipment is destined for direct reuse.

One example of a standard developed to address “adequate condition for reuse” is the PAS141 reuse standard developed in the United Kingdom. Another set of guidelines has been developed by the Partnership for Action on Computing Equipment (PACE) Working Group of the Basel Convention. The “Guideline on Environmentally Sound Testing, Refurbishment, and Repair of Used Computing Equipment” and the “Guideline on Environmentally Sound Material Recovery and Recycling of End-of-Life Computing Equipment” were adopted at the eleventh Conference of the

Parties to the Basel Convention and are available on the Basel Convention website (PACE 2013/1; PACE 2013/2).

Some producers of EEE with global business models repair and reuse their own equipment. Professional equipment such as information and communication technology equipment often receives this treatment (Gensch 2009). Some countries have repair and refurbishment facilities to which they transport equipment for repair, refurbishment and reuse from other parts of the world. Once repaired and refurbished, the equipment is redistributed. In these cases, the above requirements could block the repair and reuse of equipment if the producer works under an EoL standard.

An organization setting an EoL standard should not apply the above requirements if an equipment producer or a producer-authorized entity ships its own brand of professional equipment for reuse to a producer-authorized repair center, as this equipment should not be considered e-waste. One example of such a center would be one owned or contracted by a retailer or manufacturer for the purpose of product and equipment repair. The original equipment 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 reuse, repair and refurbishment is not disposed of or treated in any manner other than for its intended purpose. The equipment exported for these purposes shall be fully traceable to the point where it is put on the market again as used EEE, and the producer should track and provide appropriate documentation to ensure this is the case.

5.4 Storage

Site Specification

Responsible handling of e-waste requires comprehensive monitoring and supervision of the storage and transportation of e-waste, which necessitates that operators have adequate infrastructure in place to do so. EOL standards should therefore stipulate the following requirements:

- Transport vehicles at the storage site and containers used for storage must be equipped to prevent damage of the equipment and support reuse and recycling.
- Storage sites must be equipped to prevent pollution and other hazards due to damage, leakage and corrosion, or from inflammable and explosive components. This may require measures such as sealed surfaces and weatherproof coverage of storage sites (WEEE 2012).

6 Treatment

6.1 General Considerations

Preparation for Reuse and Refurbishment

Reuse of EEE offers a number of environmental and social benefits. These include saving energy and resources required for new product manufacturing and providing access to technology for those with low incomes. There are, however, drawbacks and limitations to reuse that need to be considered in the standard setting process as well. Some of these considerations are:

1. The energy efficiency of new devices may be significantly greater than that of older devices, possibly making reuse the less environmentally preferable choice.

2. Limited markets may exist for second-hand equipment, even if the equipment is in full working order.
3. Loss or theft and abuse of personal information from a previous owner may occur if media sanitization is either ineffective or not carried out. Guidelines such as those published by NIST may be useful to cite in a new standard (NIST 2006).

Recycling

Recycling operations endeavor to maintain or restore as much material as possible that is recovered from e-waste to its original quality in terms of purity and physical and chemical properties. Recycling operations are typically executed in two steps: 1) pre-processing, which prepares the e-waste for material recovery, and 2) end-processing, which consists of material recovery prior to the incineration or landfilling of any remaining material. Organizations involved in material recovery steps may not exclusively handle e-waste, and this may include organizations such as metal refineries and plastic recyclers. In developing standards, both types of organizations need to be considered and included to create a system that fully describes this processing stage.

Standards should stipulate quality recycling requirements and targets based on what can be achieved with best available technologies, while avoiding prescribing the use of certain technologies. This may include recycling targets for specific materials or weight-based recycling targets for entire programs, following the example of the European WEEE Directive (WEEE 2012). The targets should be complemented by a process-quality standard that addresses environmental, health and process efficiency criteria. Further, EoL standards may require operators to quantify and improve the efficiency of recycling operations (e.g., with parameters like the consumption of energy or other environmental media per tonne of e-waste processed, or the quantities and qualities of emissions). Details about the effectiveness and efficiency of recycling operations may be found in the Step Green Paper (Step 2012). Documentation and reporting of quantities and qualities of the various output materials from recycling processes should be obligatory for operators working under a standard.

Incineration and Final Disposal

EOL standards should require operators to use incineration and final disposal of recyclable materials only after reuse, refurbishment, recycling and material recovery options have been exhausted. Incineration or final disposal by landfilling of e-waste, its materials or fractions thereof may be cheaper than recycling in many cases. This situation sets economic incentives for final disposal or incineration instead of recycling, which may result in resource loss and environmental burdens that could be avoided through proper recycling. EoL standards should deviate from the waste hierarchy only in specific cases where sound scientific evidence indicates that treatment other than recycling yields a better environmental performance when considering the entire life cycle of the equipment in question.

Standards should also require operators to use final 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 demonstrate they have no access to such facilities, standards should require the use of the highest standard disposal and incineration facilities available in the respective region while continuing to look for more environmentally sound options.

6.2 Hazardous Materials

Pollution prevention is a main objective of e-waste treatment specific treatment of cer-

tain e-waste equipment and components due to the hazardous materials contained in them. Examples of such materials and components include: mercury in backlight of LCDs and CFLs, capacitors containing PCBs, batteries, lead and cadmium, as well as the brominated flame retardants PBDE and PBB.

Identification and Removal of Hazardous Materials

Some materials and components containing these materials need to be removed from e-waste and treated separately to avoid pollution. Examples of this are stipulated in Annex II of the WEEE Directive 2012 (WEEE 2012). EoL standards shall clearly define hazardous materials and components and require them to be removed from e-waste for proper treatment if any of the following conditions apply:

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

When a material falling under one of the above categories is identified, it needs to be removed. Removal is not exclusively limited to disassembly and manual separation, but may include manual, mechanical chemical or metallurgical handling where the hazardous materials and components are contained in an identifiable stream or identifiable parts or the stream at the end of the treatment process (WEEE 2012).
A process-integrated removal of hazardous materials and components is sufficient if the materials can be controlled, isolated and safely removed in or after the process and treated to a degree that is comparable to situations where the material is removed before treatment. During or after removal, hazardous materials or components should be treated according to the hierarchy of treatment targets. EoL standards must require that operators clearly demonstrate the removal of hazardous materials and components from the waste stream and the effective treatment of these materials in order to prevent pollution in their daily operation. Monitoring and treatment of dusty and dispersive e-waste materials as well as material with potential for fire hazards (e.g., batteries, CRTs) should also be conducted. EoL operators should track and document the downstream fate of hazardous materials and components.

Downstream 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. For example, recycling hazardous materials containing mercury should be prioritized if the release of these materials into the environment can be prevented and if there is a legitimate market for them where recycling is preferable to primary production.

- The separate treatment of hazardous materials and components may also occur within a process – that is, without initial removal – so long as the organization responsible for such treatment 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 for further processing. Hazardous materials and components that cannot be recycled and must be disposed of should be rendered inert in such a process, if possible.
- Incineration and final disposal should only be allowed in facilities equipped to handle such materials and components in a manner that avoids emissions into the environment and which have energy recovery capabilities.

Additionally, requirements should be placed on the downstream operators handling hazardous materials 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.

7 Operator Assessment and Auditing

7.1 Review Periods and Revision Process

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. Additional audits will be necessary if the operator changes processes, alters their organization or expands their activities to a new category of e-waste (ISO 17000). Periodic audits should also include unannounced control audits in order to monitor EoL operators' daily compliance between scheduled audits (ISO 17000).

7.2 Auditability Requirements

EoL standards should create transparency concerning operators' technical and organizational capacities, their knowledge and their actual successes in meeting targets and requirements in their daily operations. To facilitate this transparency, targets and requirements in a standard must be set in a way that they can be assessed for accuracy and completeness during conformity assessments (CAs).
Another important component of auditability is the operators' documentation 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. This information must be made available during CAs.

7.3 Third-Party Assessment and Auditing

Conformity assessments (CA) must reliably demonstrate that EoL operators comply with the requirements of a standard in their daily operations. Per ISO 17000, three types of CA could be performed:

- First-party assessments, where the organization reports self-audits;
- Second-party assessments, where the assessor has "user interest in the object or service" (e.g., assessment by a body contracting a particular EoL operator);

- Third-party assessments, where a person or body independent of the operator conducts the assessment.

Due to the likelihood of conflicting interest compromising first- and second-party conformity assessments, third-party CAs of EoL standards are the most reliable, and they are recommended to complement the implementation of high quality EoL standards.

ISO 17021 stipulates the essential qualities of third-party CA bodies and auditors demonstrate: impartiality, competence, responsibility, openness, confidentiality and 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.

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

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9 Annexes

A: Summary Table of Existing Standards and Regulations

The tables below provide a list of existing standards in the e-waste space, along with which recommendations presented in this paper are incorporated in each standard. The country or region indicated in parenthesis in the title column indicates the country or region of origin for a particular standard. A checkmark (✓) in a column indicates the standard or regulation of interest. Table 1 covers the incorporation of General Requirements (Sections 3, 4 and 7). Table 2 covers aspects specific to e-waste treatment. This table is intended as a reference for individuals or organizations interested in developing their own. ***Inclusion in this table does not constitute or imply endorsement or recommendation by Step or its member organizations.***

Table 1: General Requirements

Standard	Website	Legal Compliance	Financial Liabilities & Insurance	Downstream Due Diligence	EHS Management Systems	Labour & Social Responsibility	Third-Party Conformity Assessment
R2 Solutions: Responsible Recycling R2 Practices for Electronics Recyclers (USA)	http://asoft10298.accrisoft.com/r2solutions/r2practices/r2-standard/	✓	✓	✓	✓		✓
e-Stewards (USA)	http://e-ste-wards.org/certification-overview/	✓	✓	✓	✓	✓	✓
WEEELABEX (EU)	http://www.weee-fo-rum.org/news/weeelabex-standards-for-sustainable-weee-management	✓	✓	✓	✓		✓
AIIA E-SIG/PSA Interim Industry Standard - Collection, transport and recycling of end of life (EOL) televisions and computers (AU)	http://www.anzrp.com.au/uploads/9/7/2/0/9720471/interim-industry-standard.pdf	✓	✓	✓	✓		✓
Standard	**Website**	**Legal Compliance**	**Financial Liabilities & Insurance**	**Downstream Due Diligence**	**EHS Management Systems**	**Labour & Social Responsibility**	**Third-Party Conformity Assessment**
Guidelines for environmentally sound management of e-waste (IN)	http://www.cpcb.nic.in/latest/27.06.08%20guide-lines%20for%20E-Waste.pdf	✓	✓		✓		
Guidelines for E-waste Management in Kenya (KE)	http://gesci.org/assets/files/Knowledge%20Centre/E-Waste%20Guidelines_Kenya2011.pdf	✓	✓		✓		
Recycler qualification program for end-of-life electronics	http://www.epsc.ca/Documents/Recycler%20Qualification%20Pro	✓	✓	✓	✓	✓	✓

recycling – Electronics Product Stewardship Canada (CA)	gram%20FINAL%202010.pdf						
Technical Guidelines for Electrical and Electronic Waste Inventory (SE Asia)	http://www.bcrc-se-a.org/?content=publication_detail&id=36	✓		✓	✓		
Guidance Document on the Environmentally Sound Management of Used and End-of-Life Computing Equipment. Partnership for Action on Computing Equipment (PACE)[1]	http://www.basel.int/Implementation/PartnershipProgramme/PACE/PACEGuidelinesandGlossarsar-yofTerms/tabid/3247/Default.aspx	✓	✓		✓		

1: Sections 1, 2, 4 and 5 were adopted at the eleventh COP of the Basel Convention. It should be noted that Section 3 of the guidance document on the environmentally sound management of used and end-of-life computing equipment, which deals with transboundary movements, has not yet been revised. To avoid any duplications and discrepancies, the Partnership has postponed the revision of this section pending the adoption of the technical guidelines on transboundary movements of electronic and electrical waste, in particular regarding the distinction between waste and non-waste, which is currently under consideration in a separate process for submission to the Conference of the Parties.

Table 2: Handling, Transport, Storage and Treatment of E-Waste

Standard	Website	E-waste Handling	E-waste Collection	E-waste Transport	Hazardous Materials Handling	Transbounadary Shipments/ Illegal Exports Prevention	Material Flows
Responsible Recycling (R2) Practices for Electronics Recyclers – R2 Solutions (USA)	http://asoft10298.accris-oft.com/r2solutions/r2practices/r2-standard/	✓		✓	✓		
e-Stewards (USA)	http://e-ste-wards.org/certification-overview/	✓			✓	✓	✓
WEEELABEX (EU)	http://www.weee-fo-rum.org/news/weeelabex-standards-for-sustainable-weee-management	✓	✓		✓	✓	✓
AIIA E-SIG/PSA Interim Industry Standard - Collection, transport and recycling of end of life (EOL) televisions and computers (AU)	http://www.anzrp.com.au/uploads/9/7/2/0/9720471/interim-industry-standard.pdf	✓	✓	✓	✓	✓	
Standard	**Website**	**E-waste Handling**	**E-waste Collection**	**E-waste Transport**	**Hazardous Materials Handling**	**Transbounadary Shipments/ Illegal Exports Prevention**	**Material Flows**
Guidelines for environmentally sound management of e-waste (IN)	http://www.cpcb.nic.in/latest/27.06.08%20guidelines%20for%20E-Waste.pdf				✓		

Guidelines for E-waste Management in Kenya (KE)	http://gesci.org/assets/files/Knowledge%20Centre/E-Waste%20Guidelines_Kenya2011.pdf	✓	✓	✓	✓	✓	✓
Recycler qualification program for end-of-life electronics recycling – Electronics Product Stewardship Canada (CA)	http://www.epsc.ca/Documents/Recycler%20Qualification%20Program%20FINAL%202010.pdf	✓			✓	✓	✓
Technical Guidelines for Electrical and Electronic Waste Inventory (SE Asia)	http://www.bcrc-se-a.org/?content=publication_detail&id=36	✓	✓	✓	✓	✓	
Standard	**Website**	**E-waste Handling**	**E-waste Collection**	**E-waste Transport**	**Hazardous Materials Handling**	**Transbounadary Shipments/ Illegal Exports Prevention**	**Material Flows**
Guideline on Environmentally Sound Testing Refurbishment and Repair of Used Computing Equipment. Partnership for Action on Computing Equipment (PACE)	http://www.basel.int/Implementation/PartnershipProgramme/PACE/PACEGuidelinesandGlosGlossar-sar-yofTerms/tabid/3247/Default.aspx	✓	✓	✓	✓	✓	✓

NOTE:
Waste Hierarchy: Of the standards listed above, Responsible Recycling (R2) Practices for Electronics Recyclers and e-Stewards explicitly include managing material according to the waste hierarchy.
Recycling Targets: WEELABEX is the only standard of those listed that explicitly includes meeting recycling targets.

Members and Associate Members of the Step Initiative are:

(May 2014)

Full Members:

- Arrow Electronics
- Austrian Society for Systems Engineering and Automation (SAT)
- Basel Convention Coordinating Centre for Asia & the Pacific (BCRC China)
- Basel Convention Coordinating Centre for Training and Technology Transfer for the African Region (BCCC-Africa), University of Ibadan
- Basel Convention Regional Centre for Central America and Mexico (BCRC-CAM)
- BIO Intelligence Service S.A.S.
- Blueprint ERE Pte Ltd
- Center for Environment and Development for the Arab Region and Europe (CEDARE)
- Chiho-Tiande (HK) Limited
- Cisco Systems, Inc.
- Compliance and Risks
- Dataserv Group Holdings Ltd.
- Datec Technologies Ltd
- Delft University of Technology (TU Delft)
- DELL Inc.
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Dismantling and Recycling Centre Vienna (D.R.Z)
- Empa – Swiss Federal Laboratories for Materials Science and Technology
- Ericsson
- FECACLUBS-UNESCO
- Fraunhofer Institute for Reliability and Microintegration (FHG-IZM)
- Griffith University
- Hewlett Packard (HP)
- Institute for Applied Ecology (Öko-Institut e.V.)
- International Telecommunication Union (ITU)
- KERP research
- Kevoy Community Development Institute (KCDI)
- Massachusetts Institute of Technology (MIT) – Materials Systems Laboratory
- Memorial University
- MicroPro Computers
- Microsoft
- Ministry of the Environment Japan, Office Waste Disposal Management, Department of Waste Management and Recycling
- National Center for Electronics Recycling (NCER)
- Philips Consumer Lifestyle Sustainability Center
- Plataforma de Residuos Eléctricos y Electrónicos para Latinoamérica y el Caribe (Latin American WEEE Platform) (RELAC Platform)
- Renewable Recyclers
- Reverse Logistics Group Americas (RLGA)
- Secretariat of the Basel Convention (SBC)
- Secretariat of the Pacific Regional Environment Program (SPREP)
- Sims Recycling Solutions
- Swiss State Secretariat of Economic Affairs (SECO)
- Technische Universität Berlin, Institut für Technischen Umweltschutz, Fachgebiet Abfallwirtschaft (Chair of Solid Waste Management)

- Technische Universität Braunschweig,Institute of Machine Tools and Production Technology
- Thai Electrical and Electronic Institute (EEI)
- The Sustainability Consortium
- UMICORE Precious Metal Refining
- United Nations Environment Programme/Division of Technology, Industry and Economics (UNEP/DTIE)
- United Nations Industrial Development Organization (UNIDO)
- United Nations University (UNU)
- United States Environmental Protection Agency (US-EPA)
- University of Limerick
- University of Northampton (UoN), The Centre for Sustainable Wastes Management
- WEEE Help
- WorldLOOP

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- ENDA Europe
- Global e-Sustainability Initiative (GeSI)
- Vertmonde Cia. Ltd.

Step White and Green Paper Series

Number	Step Task Force	Title	Date
Green Paper #8	TF 1 "Policy"	Differentiating EEE products and wastes	14 January 2014
Green Paper #7	TF 3 "ReUse"	E-waste Country Study Ethiopia	10 April 2013
Green Paper #6	TF 1 "Policy"	E-waste in China: A Country Report	05 April 2013
Green Paper #5	TF 1 "Policy"	Transboundary Movements of Discarded Electrical and Electronic Equipment	25 March 2013
Green Paper #4	TF 4 "ReCycle"	Recommendations on Standards for Collection, Storage, Transport and Treatment of E-waste	22 June 2012
Green Paper #3	TF 1 "Policy"	International policy response towards potential supply and demand distortions of scarce metals	01 February 2012
Green Paper #2	TF 2 "ReDesign"	Worldwide Impacts of Substance Restrictions of ICT Equipment	30 November 2011
Green Paper #1	TF 1 "Policy"	E-waste Indicators	15 September 2011

Number	Step Task Force	Title	Date
White Paper #4	TF 4 "ReCycle"	Recommendations for Standards Development for Collection, Storage, Transport and Treatment of E-waste	02 June 2014
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
White Paper #2	TF 3 "ReUse"	One Global Understanding of Re-use – Common Definitions	5 March 2009
White Paper #1	TF 1 "Policy"	E-waste Take-back System Design and Policy Approaches	28 January 2009

All Step publications are online available at http://www.step-initiative.org/publications/.

About the Step Initiative:

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

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

Our prime objectives are:

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

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

Step's core principles:

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

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

UNITED NATIONS UNIVERSITY