ELECTRONICS DISPOSAL EFFICIENCY (EDE): AN IT RECYCLING METRIC FOR ENTERPRISES AND DATA CENTERS

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Executive Summary

The Green Grid Association (TGG) is a non-profit, open industry consortium of end users, policy makers, technology providers, facility architects, and utility companies that works to improve the resource efficiency of information technology and data centers throughout the world. Over the past few years, TGG has developed a series of metrics for use in evaluating and enhancing data center operations. This series includes power usage effectiveness (PUE™), data center energy productivity (DCeP™), energy reuse effectiveness (ERE™), data center compute efficiency (DCcE™), and others. The Green Grid now proposes a new metric—electronics disposal efficiency (EDE)—to increase industry awareness regarding the responsible disposal of IT assets. By providing a simple metric that is easy to use, The Green Grid believes that organizations will be able to measure themselves and set goals to improve how they dispose of IT assets. The EDE metric complements the data center maturity model (DCMM), which contains clear goals and direction for improving energy efficiency and sustainability throughout a data center.

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I. Introduction

Discarded electronics and electrical equipment (EEE) entering the waste stream is known globally as e-waste or waste electronics and electrical equipment (WEEE). Examples of WEEE include discarded computers, TVs, mobile devices, home entertainment products, toys, and even white goods such as refrigerators, washers/dryers, stoves, etc. that have reach their end of life (EOL).

A variety of organizations have helped define and monitor WEEE worldwide. However, the global community is in need of a user-based metric to quantify how well a corporate consumer of IT EEE responsibly manages it once it has been used and is no longer useful to the corporate consumer (i.e., it is at its end of current use or EOCU) or when it has reached its EOL. In response, The Green Grid (TGG) set out to develop a means for corporate consumers and electronics manufacturers to measure their success in responsibly managing their used EEE (UEEE) and WEEE. The goal is to provide them with an easy way to calculate and measure that success over time.

TGG believes that its new electronics disposal efficiency (EDE) metric will incent positive behavior and influence change on a global scale. Once the EDE metric is adopted by a broad base, the hope is that more UEEE and WEEE will enter both the responsible reuse and recycling channels. When IT EEE reaches its EOCU and EOL (which may be well past its depreciation age), organizations will have established management processes that extend the life of used IT EEE and maximize recycling of materials while minimizing the quantity of material delivered to final disposal and the impact on the environment at each stage of the reuse and EOL processes.

In addition, as organizations progress along the data center maturity model (DCMM), responsible UEEE and WEEE management has the potential to make a positive impact on their bottom line.

It is important to note that TGG intends for this metric to be used as a way for organizations to measure themselves and improve over time, rather than as a score to be compared with other entities. TGG has deliberately set expectations high, in the belief that as more organizations adopt the EDE metric and ask for greater transparency in the process, responsible reuse, recycling, and disposal of IT assets will improve on a global scale.

TGG based certain concepts in this white paper on work previously conducted and documented by Emerson Network Power in a white paper titled "Recycling Ratios: The Next Step for Data Center Sustainability."[1]

WORKING DEFINITIONS

The following section defines the acronyms and terms used throughout this white paper.

Decommissioned EEE: Electronics and electrical equipment (EEE) that leaves the control of the organization.

EEE: Electronics and electrical equipment. The European Union's Waste Electrical and Electronic Equipment (EU Directive 2012/19/EU) defines a number of categories for electrical and electronic equipment that apply to WEEE. One category in particular, Category 3, covers IT and Telecommunications Equipment. Per Directive 2012/19/EU, OJ L 197, p. 55 of 24.7.2012, Category 3 includes:

- Centralized data processing

[1] http://www.emersonnetworkpower.com/en-US/Documents/EDC/Market%20Position%20Paper%20-%20Recycling%20Ratios_6.pdf

  - Mainframes, minicomputers, printer units
- Personal computing
  - Personal computers (CPU, mouse, screen, and keyboard included), laptop computers (CPU, mouse, screen, and keyboard included), notebook computers, notepad computers, printers, copying equipment, electrical and electronic typewriters, pocket and desk calculators, and other products and equipment for the collection, storage, processing, or communication of information by electronic means
  - User terminals and systems, facsimile (fax) machines, telex, pay telephones, cordless telephones, cellular telephones, answering systems, and other products and equipment used for transmitting sound, images, or other information by telecommunications

EOCU: This acronym stands for "end of current use" and means that the equipment is no longer being used for its last-identified purpose. If a piece of IT EEE is going to be repurposed or reused within an organization, that piece of IT EEE should not be considered in metric calculations.

EOL: This stands for "end-of-life." When used to describe computing equipment, it means an individual piece that is no longer suitable for use and is intended for dismantling and recovery of spare parts or is destined for recycling or final disposal. It also includes off-specification or new computing equipment that has been sent for recycling or final disposal.

Organization: An entity not limited to, but including any one of the following: a corporate consumer of IT EEE, government agency, charity, non-profit, or not-for-profit entity.

UEEE: Used electronics and electrical equipment.

WEEE: Waste electronics and electrical equipment.

II. The Electronics Disposal Efficiency (EDE) Metric

The Green Grid's EDE metric is simple in its basic formulation. It is the percentage, based on unit or product weight, of decommissioned IT EEE at its EOCU or EOL that is disposed of through known responsible entities.

The basic equation is:

$$EDE = \frac{Wt_{"Responsibly\ Disposed"}}{Total\ Wt_{"Disposed"}}$$

Where:

$Wt_{\text{"Responsibly Disposed"}}$ is the total weight of decommissioned IT EEE at its EOCU or EOL that is managed through known responsible entities.

Total $Wt_{\text{"Disposed"}}$ is the total weight of decommissioned IT EEE at its EOCU or EOL.

In all cases, EDE ≤ 100%.

Although the EDE metric can be stated simply, calculating it requires an organization both to know the weight of those products and components that have been decommissioned and to identify the destination for those products and components as they leave its control.

In order to calculate the weight of products that have been decommissioned, certain boundaries must be applied to the EDE metric. These are defined as all IT EEE that is decommissioned and disposed of by the organization.

The EDE's numerator is calculated by summing the total weight of all EOCU and EOL IT EEE—its parts and components—for which responsible disposal has been completed in accordance with the definition of "responsible" discussed below in section III. This means that the organization has delivered the material to a third party that has been subject to appropriate due diligence prior to receiving the materials or that has been certified under appropriate electronics recycling standards. These standards include Recycling Industry Operating Standard (RIOS), Responsible Recycling (R2), eStewards, and others such as SA8000, IDC's Green Recycling and Asset Disposal for the Enterprise (G.R.A.D.E.), WEEE Label of Excellence (WEEELABEX), and Ontario Electronic Stewardship.

While the EDE calculation outlined above does not require specifying the product and component weights that exit the organization through each channel, organizations using the EDE metric may, for their own management purposes, calculate the metric's numerator and denominator by separately calculating the material streams entering each type of channel (e.g., "Whole System Reuse," "Component Reuse," or "Recycling"). In the EDE metric equation below, "Waste" represents material that is not recovered and that is sent to final disposal (e.g., landfilling or incineration as treatment) or other final destination. Defining waste in

this manner will enable organizations to review the disposal stream that was used for UEEE and determine if opportunities exist to better utilize the available resources.

For those using the EDE metric who would like to track the different channels separately, TGG recommends the following approach:

$$Total\ Wt_{"Disposed"} = Wt_{"Whole\ System\ Reuse"} + Wt_{"Component\ Reuse"} + Wt_{"Recycling"} + Wt_{"Waste"}$$

And:

$$Wt_{"Responsibly\ Disposed"} = Wt_{"Certified\ Reuse\ (System)"} + Wt_{"Certified\ Recover\ (Component)"} + Wt_{"Certified\ Recycle"}$$

III. The Definition of "Responsible"

The Green Grid supports the notion of "resource, not waste" when considering EOCU and EOL IT EEE. In other words, organizations should view EOCU and EOL IT EEE as a significant resource because it contains valuable and rare materials.

When applied to the EDE metric, the term "responsible" means that the management processes referred to above adhere to standards that minimize the possible environmental impact of the IT EEE's disposal and maximize the recovery of embedded materials. Equipment management processes should seek to maximize the recovery of usable components, materials, and energy before resorting to final disposal and do it in a way that prevents impacts to the environment and human health. Generally, that means delivering the material to a third party that has been certified under appropriate electronics recycling standards by a third-party certification body that has been accredited by a recognized accreditation body such as RIOS, R2, eStewards, or others, including SA8000, IDC's G.R.A.D.E., WEEELABEX, and Ontario Electronic Stewardship. When materials are processed in the recycling stream, organizations can obtain certificates of recycling as proof of compliance from the downstream partners.

In some cases, organizations that are end users of information technology may have their own alternative approaches to R2, eStewards, or other certification systems. Organizations may be able to use such programs when applying the EDE metric if the following conditions exist:

- An outside entity has reviewed the internal program and has been able to verify that the program is set up in such a way that it is equivalent to or better than baseline programs currently available (such as R2 or eStewards).

- The organization has established means for providing governance controls over its internal program. For example, an organization could leverage the ISO 14001 specification for this, provided that the ISO 14001 is focused specifically on the program.
- The organization has established a regular program whereby a third party provides oversight of the internal program, including scheduled audits to ensure that the organization is complying with the internal guidelines set up within the program and verified through an initial review.

In all cases, The Green Grid would recommend against applying the metric using internal programs where the organization has both defined the program and relies solely on internal processes for review with respect to compliance (i.e., self-certification).

WHOLE SYSTEM REUSE

The organization generating EOCU or EOL IT EEE must make all reasonable efforts to ensure that the recipient of the EOCU and EOL IT EEE, the intended use of the EOCU and EOL IT EEE by the recipient, and the final management of the EOL IT EEE is done in a responsible manner, including its optional return to its original source (i.e., the organization that generated the EOCU and EOL IT EEE). This is necessary to ensure that:

- EOCU IT EEE is being used according to its functional design.
- EOL IT EEE is being managed in an environmentally responsible manner once it reaches its EOL.

PARTIAL SYSTEM REUSE

The approach to partial system reuse should be identical to that of whole system reuse (see above). Components removed during a partial system refresh or refurbishment operation should either be reused in their originally intended capacity or recycled through responsible channels.

PARTS AND COMPONENTS REUSE

The company that is responsible for disassembling IT EEE for reuse of its parts and components must do so in a responsible manner as defined above.

RECYCLING

As described above, the recycling company must be certified to an electronics recycling standard by a third-party certification body that has been accredited by a recognized accreditation body such as RIOS, R2, eStewards, or others, including SA8000, IDC's G.R.A.D.E., WEEELABEX, and Ontario Electronic Stewardship.

When materials are processed in the recycling stream, organizations can obtain certificates of recycling as proof of compliance from the downstream partners.

CERTIFICATION AND ACCREDITATION

At a minimum, processing facilities should be certified by third parties that have been accredited by a recognized accreditation body that ensures that downstream processing is audited and that IT EEE, parts, and components are handled in a responsible manner in the final processing and disposal facilities. Organizations can use certifications independently or combined with others. Certifications that could be used include RIOS, R2, eStewards, and others such as SA8000, IDC's G.R.A.D.E., WEEELABEX, and Ontario Electronic Stewardship.

Accepted accreditation bodies include the ANSI-ASQ National Accreditation Board (ANAB) and AQA.

REPORTING

For an organization to have an accurate, useful EDE result, the disposal and recycling certificate for the total weight of IT EEE collected for processing *must* be provided to the organization by those entities disposing of its EOCU or EOL IT EEE by way of reuse (including refurbishment), recycling, and/or final disposal. In addition, the following need to be included as applicable:

- Total weight of used electronics received
- Percentage of used electronics refurbished
- Percentage of used electronics resold
- Percentage of used electronics recycled
- Percentage of used electronics landfilled
- Percentage of used electronics incinerated (as treatment and for waste energy)

[Note: Annual reporting against the EDE metric is assumed unless the timeframe is otherwise stated.]

SECURITY CONCERNS

Although security is not directly related to environmental concerns about EOCU and EOL IT EEE management, it is a crucial consideration when selecting a partner to handle the reuse, recycling, and/or disposal process. In some instances, proper data destruction—such as destruction that is conducted according to the National Institute of Standards and Technology (NIST) guidelines SP800-88 (see www.nist.gov)—may be possible only through physical destruction of data-carrying devices, which may have an impact on the ability to reuse or

recycle the affected IT EEE. The EDE metric assumes that all security considerations appropriate for the organization have been addressed.

IV. Development of the EDE Metric

In developing its user-based EDE metric, The Green Grid sought to:

- Provide a way for organizations to measure the responsible management (reuse, recycling, and disposal) of IT EEE that reaches EOCU or EOL.
- Provide guidance as to what responsible management entails.
- Ensure that entities are responsibly handling IT EEE management pathways.
- Maintain recycling and reuse standards.

TGG aligned the EDE metric with the following standard business-performance requirements:

- **Business alignment**
  - Tracking metrics consumes resources both for data collection and analyses. Metrics need to provide insight into an entity's business performance, issues, and needs.
- **Honest assessment**
  - Creating metrics that make the performance of an individual or organization appear favorable has no value and can be detrimental to that organization's ability to establish an effective performance improvement plan for the efficient management of EOCU or EOL IT EEE.
  - Metrics need to be able to provide an honest assessment, whether positive or negative.
- **Consistency:**
  - Identified components in any metric need to be defined at the outset and remain constant.
  - Criteria and calculations need to be consistent with respect to time.
- **Repeatability and reproducibility:**
  - Measurements should have little or no subjectivity.
- **Actionability:**
  - Metrics should be purposeful; measurements conducted against a metric should answer "What is being measured and why?"
  - Include only those metrics that will be acted upon; that is, either remove a degradation problem or hold the gain.
  - When a metric's result is unsatisfactory when measured against the users' objectives and targets associated with the metric, organizations need to be prepared to conduct root-cause analysis and take corrective or preventive actions.

- **Time-series tracking:**
  - Metrics should be captured in time-series format; historical trending will provide more value than a snapshot of a point-in-time activity.
  - Time-series tracking can describe trends and separate special-cause from common-cause variability in predictable processes.
- **Peer comparability:**
  - The EDE metric is meant to be used by an organization to improve its own performance in this area over time, not as an instrument to compare itself with others across industry peer groups.

In order to promote responsible disposal of EOCU and EOL IT EEE on a global basis, metrics should be international and used by all corporate consumers and IT EEE manufacturers.

TGG's designated task force took the following actions to develop the EDE metric:

- Recruited a multinational task force consisting of individuals from corporate consumers and manufacturers of IT EEE, many with first-hand experience dealing with responsible management methods for EOCU and EOL IT EEE
- Held weekly work sessions
- Defined terms (e.g., "responsible") with the eventual goal of alignment with commonly accepted definitions
- Defined scope regarding which IT EEE is included and which organizations will be measured
- Reviewed existing standards (e.g., RIOS, R2, e-Stewards, PACE)
- Collaborated with the United Nations initiative Solving the E-Waste Problem (StEP)
- Developed a white paper with reviews by and input from other organizations involved with management of UEEE and WEEE, including RackSpace and the organizations that participated in the creation of this white paper

V. Scope

As the task force both planned and developed this document, it identified a number of key questions that are frequently asked with respect both to the overall EDE metric and to what is considered and not considered within the metric itself. This section provides commentary on both of these and includes a summary of the metric's scope definitions in Table 1.

GOALS FOR EDE METRIC DEVELOPMENT

The primary goal for the EDE metric is to provide a means for IT end users to measure their progress in ensuring that, as they decommission IT EEE and move those assets out of their organization, those assets are managed (refurbished, reused, recycled, and disposed of) through responsible means. As such, this is an end-user metric and not intended to be a metric for IT EEE manufacturers to measure their progress in recovering and managing EOCU and EOL assets responsibly. Of course, many, if not all, IT EEE manufacturers are also end users. In that context, manufacturers can take advantage of the EDE metric with regard to the responsible management and disposal of the IT EEE they use themselves.

Table 1. Summary of scope definitions for metric development

Area	In Scope	Out of Scope
Target User	Organizations that consume IT EEE	IT EEE manufacturers
Metric Goals	Incenting responsible disposal of IT EEE at EOCU and EOL	Incenting particular types of disposal
Definition of Responsible	Reference or citation of existing third-party definitions for "responsible disposal" Initial definition of "responsible disposal" if disposal pathways are identified where clear industry definitions do not exist	New definition of "responsible disposal," except in the case where there are no clear industry definitions for specific EOCU and EOL disposal pathways
Glossary	Existing industry definitions for domain-related terms	Re-definition or initial definition of domain-related terms
Use Model	Comparison of a single organization's progress over time	Comparisons between competing organizations

Another key task force decision was *not* to make specific recommendations with respect to EOCU and EOL IT EEE disposal pathways. Currently, there is substantial debate in the industry on this issue, and various tradeoffs arise from different approaches. For example, if a particular piece of equipment is significantly less energy efficient than the equipment that could potentially replace it, is the right approach to reuse or recycle the original equipment? The task force believes that the industry will be addressing these issues over the next few years. Attempting to define a point of view with respect to preferred disposal pathways may hinder development and adoption of the initial goal of the EDE metric: to incent responsible disposal of EOCU and EOL IT EEE, regardless of disposal path chosen.

The task force is also very aware that The Green Grid's current domain competencies lie in understanding resource consumption and resource efficiency in the data center and other enterprise IT environments. There

are a number of existing organizations that have been working on issues around WEEE for some time. TGG hopes to supplement and promote that work by providing metrics that incent the consideration and adoption of those operational approaches to managing IT EEE at EOCU and EOL. To that end, The Green Grid will refer to and make the most of existing industry and domain work wherever possible. It is not TGG's intent either to supplant or create alternatives to current industry efforts but rather to put those efforts into a usable context for corporate consumers of IT EEE, commercial IT professionals, and organizations.

TGG recognizes that when metrics such as EDE are introduced, there is a strong incentive for organizations to use them as a basis for competition. The task force believes that the EDE metric will be most useful for those organizations looking to measure and document their own improvement over time. Therefore, TGG discourages the use of this metric as a comparator between different corporate consumers of IT EEE or between organizations.

ISSUES OF SCOPE FOR EDE METRIC CALCULATION AND USE

To provide a metric that is both meaningful and practical, the task force had to consider what should and should not be included within the metric itself, beginning with the scope of the metric within a reporting organization. While most of The Green Grid's work to date has been tightly focused on data center operations, in this case, the task force believes that the EDE metric must apply to all environments within an organization where IT EEE is hosted, used, or operated. Responsible disposal of IT EEE is an issue that applies throughout the enterprise; it is not specific to the data center. This also means that, in order to calculate and report a meaningful number, an organization must include all of its waste streams from around the globe and not limit calculation to particular regions.

Next, the task force identified which types of equipment classes must be considered when calculating EDE. To do so, it referred back to two key principles. First, wherever domain-specific definitions exist, the task force should initially incorporate those into the metric, as opposed to creating new definitions. Second, given that the organizational scope of the metric is the entire enterprise, the types of IT EEE typically found in office or data center environments must be included in EDE calculations. (See Table 2 for more on EDE scope.)

Table 2. Summary of scope definitions for metric calculation

Area	In Scope	Out of Scope
Asset Types	All IT and telecommunications equipment described under Category 3 of Annexes 1 and 2 of Directive 2012/19/EC (WEEE)	Any equipment not described in Directive 2012/19/EC or described in Directive 2012/19/EC under categories other than Category 3
Ownership (Option 2)	IT EEE either owned or operated by the reporting organization where the organization controls the decision as to when and how IT EEE (that has reached its EOCU or EOL) is to be decommissioned. This includes IT EEE that is leased, owned, operated, and hosted within the reporting organization's facilities.	IT EEE used by a reporting organization that has no control over when or how the IT EEE is decommissioned Assets not operated by the organization, regardless of whether the assets are owned or leased
Internal Reuse	EOCU IT EEE that is not being repurposed within the organization	EOCU IT EEE that will be reused within the organization
Organizational Scope	All global facilities owned or leased by an organization that contain IT EEE and are covered in the scope of this white paper	Facilities owned or leased by an organization that do not contain IT EEE covered in the scope of this white paper
Location	All appropriate global facilities	Facilities owned or leased by an organization that do not contain IT EEE covered in the scope of this white paper

Once the task force agreed on the scope of the metric within a reporting organization and which types of equipment were to be included, it then had to consider ownership issues as well as what constitutes EOCU and EOL.

VI. Management of Decommissioned (EOCU/EOL) IT EEE

When applied to the EDE metric, the phrase "management methods for decommissioned equipment" includes the methods of relinquishing control over IT EEE that are described in the subsections below. This white paper is not intended to provide guidance as to which path an individual piece of IT EEE should follow. Within the scope of the EDE metric, the following management methods are considered environmentally responsible methods of handling decommissioned IT EEE once it leaves the direct control of an organization.

REUSE

Whole System

Whole system reuse is the use of used IT EEE for its originally intended purpose. For example, a monitor will be reused as a monitor or a personal computer will be reused as a personal computer or small server. The IT EEE may also be subject to repairs, refurbishment, or upgrades as part of the reuse process. The Green Grid recommends that the equipment pass a technology and functionality review before being donated to ensure that it has not exceeded its useful life. The donator is responsible for providing IT EEE that is technologically current and functional (or that can be easily repaired) and that can still fulfill its originally intended purpose. Whole system reuse can include:

- Donation of IT EEE to a charity, public institution (such as a school or hospital), private institution, employee, or other receiving entity
- Whole system resale to an employee, vendor, or third-party reseller

IT EEE will be considered responsibly managed if the following conditions are met for whole system reuse and/or resale:

- Organizations request that receiving entities commit to responsibly managing IT EEE assets when EOCU or EOL is reached.
  - This includes committing not to resell UEEE into countries that are not part of The Organisation for Economic Cooperation and Development (OECD) if the reseller knows or has reason to believe that the equipment and/or parts will not be used for its originally intended purpose without the need for disassembly or disposal.
  - Originating entities provide a take-back option.

In all cases, whole system reuse and/or resale must be for the purpose of using the IT EEE according to its originally intended function.

Partial System (Refurbishment)

Partial system reuse is similar to whole system reuse in that the expectation is that the system is being upgraded or repaired for return to its originally intended use. Note that a server may go through component-level upgrades in order to meet an entity's desired use case. In all cases of partial system reuse, the components being upgraded or replaced must follow a responsible EOCU or EOL disposal pathway.

Component Reuse

In addition to whole system reuse and partial system reuse, individual parts or components and groups of parts or components may also be reused or resold. The IT EEE may be disassembled and its parts and components reused to repair or upgrade other similar equipment. For example, a disk drive from one system may be removed, erased, and used in another system. Component reuse requires that the entire component be reused for its originally intended purpose. The IT EEE component or part may also be subject to repairs, refurbishment, or upgrades as part of the reuse process. The Green Grid recommends that these parts and components pass a technology and functionality review before being donated to ensure that they have not exceeded their useful lives. The donator is responsible for providing IT EEE parts and components that are technologically current and functional (or that can be easily repaired) and that can still fulfil their originally intended purposes.

RECYCLING

IT EEE recycling means the complete reduction of the equipment in one or more electronics recycling facilities for the purpose of recovering the embedded materials. Recycled materials should then serve as feedstock in another manufacturing process.

LANDFILLING AND INCINERATION

In some cases, the reuse or recycling of EOCU or EOL IT EEE will be difficult to achieve. Therefore, some materials will require final disposal at properly licensed and permitted facilities. Final disposal includes incineration as treatment, incineration with energy recovery, and confinement in secure landfills. Although landfilling or incineration may be necessary for final disposal of certain IT EEE components that have no value through recycling or cannot be recycled in the region in question, the remaining material should be used for energy recovery whenever possible and where feasible. Landfilling or incineration of whole systems should be avoided.

VII. Organizational Involvement in EOCU Material Streams

In order to analyze material streams resulting from the disposal of IT EEE at EOCU or EOL, it is important to understand the different actors involved in these processes. Organizations may be contributors to a material stream (at the UEEE, EOCU, or EOL stages), recipients of a material stream, or, in some cases, both. (See Table 3 for a summary of the descriptions below.)

Primary contributors to material streams include:

- Corporate consumers of IT EEE
  - These organizations are the intended audience for the EDE metric. They may directly own the IT EEE being disposed of at its EOCU or EOL, and they may also be lessees of IT EEE that is owned by another organization.

Primary recipients of UEEE at EOCU or EOL include:

- Original equipment vendors
  - These organizations are responsible for the manufacture and/or initial sales/distribution of the IT EEE that is being disposed of.
- Asset recovery services organizations
  - These are organizations with a broad charter to receive EOCU and EOL IT EEE and identify how best to manage its disposal, typically with an eye toward maximizing the value of that equipment during its reuse, recycling, and disposal.
- Recyclers
  - These organizations receive EOCU and EOL IT EEE through disposal streams and specialize in recovering value through the recovery and recycling of components or materials from full systems.
- Waste management companies
  - These organizations specialize in the final disposal of materials from EOCU and EOL IT EEE that are not under consideration for reuse or recycling.

In general, most of the organizations in this recipient category use triage processes upon receipt of EOCU and EOL IT EEE to determine how best to extract value from the received material. They will then process that material or deliver it to a downstream organization, based on the results of each assessment.

Organizations that may be recipients of EOCU and EOL IT EEE with potential future contribution of the received material to a different stream include:

- Donatees
  - Typically non-profit or education organizations, although others are possible, donatees receive EOCU or EOL IT EEE that no longer meets the needs or operating criteria of the original owner. These organizations usually do not have any subsequent material-processing capability other than minor repair and refurbishment.

- Refurbishers
  - These organizations specialize in the reconditioning of used IT EEE for reuse. Typically, refurbishers will receive EOCU and EOL IT EEE that is technologically current. Refurbishing may include functionality or cosmetic testing to determine what can be reused (i.e., "mop and glow" processes).
- Lessors
  - These organizations own IT EEE that is being leased and operated by a separate entity. Typically, lessors will take UEEE back after lease completion and will assess reuse, resale, recycling, and final disposal options accordingly.

Table 3. Organizations versus processes

	Original System Use	Material Triage	System Reuse	Component Reuse	Recycling	Incineration	Landfilling
Organizational Consumers of IT EEE	✓		✓				
Original Equipment Vendors		✓	✓	✓			
Asset Recovery Services Organizations		✓	✓	✓			
Recyclers		✓			✓		
Waste Management Companies		✓				✓	✓
Donatees			✓	✓			
Refurbishers		✓	✓	✓			
Lessors		✓	✓				

VIII. Potential EDE Use Models

Potential use models for the EDE metric are numerous and can extend throughout an organization. As with TGG's Data Center Maturity Model (DCMM), use of the metric can evolve through four stages, outlined below, as data reliability transitions from back-of-the-envelope calculations to auditable results.

1) Initially, the EDE metric can be used internally to understand existing operations. Although this application may be inaccurate and based more on estimates than facts, it can help organizations gauge their performance and learn about current operations.

2) As information becomes more refined, organizations can have greater confidence in their numbers, which will allow them to formulate performance goals around EOCU and EOL IT EEE disposal.

3) More mature information can become a reportable metric in corporate responsibility reports. The metric's auditable results can then be publicly disclosed through the Global Reporting Initiative (GRI) or other disclosure methodology.

4) Eventually, the EDE metric will provide a standard measurement that allows organizations to evaluate their progress toward achieving internal goals.

Ongoing use of the EDE metric will help organizations derive additional value from their EOCU and EOL IT EEE. Responsible disposal encourages product refurbishment and reuse. Organizations are likely to aggressively pursue refurbishment and reuse options that they may have overlooked in the past. In addition, responsible disposal can lead toward increased avoidance of costs related to EOL IT EEE management.

Responsible management of EOCU and EOL IT EEE helps minimize corporate risk, including:

- Brand/reputation damage if EOCU or EOL IT EEE is found to harm human health and/or the environment
- Data loss or misuse
- Disruption of supply chain or site operations
- Decreased credibility in the marketplace
- Decreased shareholder value
- Fines and penalties from regulatory authorities

The EDE metric highlights these risks for organizations and helps drive strategic decisions to reduce risk and responsibly dispose of UEEE. Many organizations are likely unaware of how they dispose of UEEE. Adopting an industry-wide metric that measures responsible disposal will bring these issues to the forefront.

IX. Guidelines for Application of the EDE Metric

While The Green Grid will leave a full discussion of operationalizing the EDE metric to a future white paper, the task force did feel it important to provide some initial guidance on how to calculate the metric and to offer a sample template for organizations to use as they investigate. The sample template—Figure 1 below—is not

meant to be officially prescriptive but merely to provide one approach that an organization can use to calculate its EDE.

The approach shown in Figure 1 focuses on identifying the various waste streams within an organization, documenting the materials processed through each waste stream, and then aggregating the data into a final number. In this case, a waste stream is defined as the movement of material from one of the overall organization's areas (the source organization) to a different area responsible for managing the material (the recipient). Organizations will likely have multiple waste streams. Smaller organizations may have few streams, but larger ones are likely to have tens or possibly hundreds of waste streams.

Figure 1 includes the following columns:

- **ID:** Identifier for waste stream
- **Description:** Description of the waste stream
- **Source Organization:** Team or group that is responsible for, and is decommissioning, the equipment
- **Recipient/Receiver/Donatee:** Organization that is receiving the equipment
- **Type of Equipment:** Description of delivered equipment
- **Report Start Date:** Day the reporting period begins
- **Report End Date:** Day the reporting period ends
- **Total Disposal Weight:** Weight, in metric tons (mts), of material moving through the waste stream during the reporting period
- **Responsible Disposal Weight:** Weight, in metric tons (mts), of material that can be traced as entering a process where it will be handled according to responsible disposal guidelines
- **Third-Party Cert/Audit:** Flag as to whether or not there is third-party oversight involved with this waste stream
- **Comments:** General field for additional information

To use the template, an organization would:

- Identify all relevant waste streams.[2]
  - Once all waste streams have been identified, future calculations will involve verifying the current list, as opposed to creating an initial list.

[2] In fact, success in identifying and documenting the waste streams of an organization can be of immense value to some organizations, regardless of their eventual success at calculating the EDE metric.

- Document source organizations and recipient organizations for each waste stream.
- Document the type of equipment moving through the stream.
- Calculate the relevant numbers for the stream by reporting period.

Initial calculation of EDE will result in an organization identifying baseline numbers. From there, TGG encourages organizations to improve their ability to responsibly manage EOCU and EOL IT EEE over time by following the guidelines stated in this white paper.

Initial applications of the EDE metric include:

- Understanding the current state
  - How much IT EEE is being disposed?
    - Determining and reporting IT EEE disposal by country/geographic region, instead of using an aggregate global number, provides a more granular view of an organization's current state.
  - Do all receiving entities have downstream guarantees of responsible disposal?
  - What areas of the EOCU and EOL IT EEE disposal processes are unverifiable?
- What changes to the IT EEE life cycle need to be made to improve results?

An EDE result of 100% is meant to be an aspirational goal. Some countries and geographic areas may lack the right infrastructure or facilities to permit the 100% target. TGG does not intend for an EDE result of less than 100% to imply that IT EEE is being handled irresponsibly, as it may not be possible in all locations.

Sample Waste Stream List for Calculation of TGG's EDE Metric

ID	Description of Waste Stream	Source Organization	Recipient / Receiver / Donatee	Type of Equipment	Report Start Date	Report End Date	Total Disposal Wt. (lbs)	Responsible Disposal Wt. (lbs)	Third-Party Cert/Audit	Comments
1	Data Center IT Equipment - 1	Dallas Data Center	Bob's Reuse-IT Warehouse	Servers, Storage, Networking	2/1/2011	1/31/2012	26,000	22,000	Y	Bob's --> R2
2	Data Center IT Equipment - 2	Fort Worth Data Center	Ditches'R'Us	Servers, Storage, Networking	2/1/2011	1/31/2012	14,000	0	N	DRU does not allow photographs
3	Office IT Equipment -- Dallas	Dallas Facilities - Bldg 2	Bob's Reuse-IT Warehouse	Laptops, DTs, Monitors	2/1/2011	1/31/2012	8,000	7,000	Y	Bob's --> R2
4	Kenya Call Center	Kenya Call Center	Harold's Burn-o-matic	Desktops, Monitors, Cables	2/1/2011	1/31/2012	2,000	0	N	You don't want to know
	TOTAL						50,000	29,000		
				EDE from	2/1/2011	1/31/2012		58.0%		

Figure 1. Sample EDE calculation template

X. Background on Existing Work

There are several national and international efforts underway to address both waste electronics disposal and responsible recycling principles. These efforts currently concentrate on consumer and commercial waste electronics disposal and specifically aim to end the practice of unauthorized "dumping" of waste EEE (WEEE) in developing nations. Section X discusses the two most significant multi-stakeholder efforts to address waste electronics disposal: The Partnership for Action on Computing Equipment (PACE) and the United Nations initiative Solving the E-Waste Problem (StEP). In addition, it describes recycler-focused standards initiatives such as Responsible Recycling (R2) Practices, e-Stewards Standard for Responsible Recycling and Reuse of Electronic Equipment (e-Stewards), and the European Union–based WEEE Label of Excellence (WEEELABEX) standards for sustainable WEEE management. Other WEEE recycling standards may exist in other regions or countries around the world, but this section highlights some of the most important ones today.

ELECTRONICS DISPOSAL EFFORTS

PACE and StEP serve as two primary examples of responsible WEEE disposal standards currently underway. The following paragraphs outline these efforts using the descriptions provided by their respective websites.

Partnership for Action on Computing Equipment (PACE)

The Partnership for Action on Computing Equipment (PACE) was launched at the ninth meeting of the Conference of the Parties to the Basel Convention, which took place in Bali, Indonesia, June 23-27, 2008. PACE is a multi-stakeholder partnership that provides a forum for governments, industry leaders, non-governmental organizations (NGOs), and academics to tackle the environmentally sound management, refurbishment, recycling, and disposal of used and end-of-life computing equipment.

PACE is intended to increase environmentally sound management of used and end-of-life computing equipment by taking into account social responsibility and the concept of sustainable development as well as promoting the sharing of information on lifecycle thinking. (Additional information on PACE efforts can be found at http://basel.int/industry/compartnership.)

Solving the E-Waste Problem (StEP)

Solving the E-waste Problem (StEP) is an initiative of various United Nations organizations seeking a solution to the global problem of WEEE. Prominent members from industry, governments, international organizations, NGOs, and academia actively participate in StEP, which initiates and facilitates approaches to sustainable handling of WEEE. Through analysis, planning, and pilot projects, five task forces develop feasible, just, and environmentally safe solutions for the WEEE problem. (Additional information on the StEP efforts can be found at www.step-initiative.org.)

RECYCLER-FOCUSED EFFORTS

The three most significant efforts focused on electronics recyclers are R2, e-Stewards (both from the United States), and the EU's WEELABEX project. The first two require that recyclers seek third-party certification to standards that the two organizations have developed. WEEELABEX, launched by the EU, is still in process and focuses on recycler performance with respect to a broad range of WEEE, from large appliances (refrigerators, washers, dryers, etc.) to electronics (desktops, laptops, etc.). These three efforts are highlighted below, using the descriptions provided by their respective websites.

Responsible Recycling (R2) Practices

The Responsible Recycling Practices for Use in Accredited Certifications Programs (R2) Standard was developed through a multi-stakeholder process convened by the U.S. Environmental Protection Agency (EPA). The goal was to create a voluntary, market-based mechanism for ensuring best practices, which would also provide essential information/assurances to prospective electronics customers.

The R2 Practices Standard was developed through a transparent, balanced, consensus-based process that took three years from start to finish. The multi-stakeholder group included representatives from the U.S. EPA; regulators from state agencies; electronics recyclers, refurbishers, and their trade associations; OEMs/customers of electronics recycling services; and NGOs. Representatives from environmental justice organizations participated actively for much for the R2 development process but withdrew toward the end.

Once the standard was finalized, it was reviewed and approved by ANAB, the organization that provides accreditation to the certification bodies that conduct the third-party audits of electronics recycling facilities. (Additional information on the R2 Practices and R2-certified recyclers can be found at http://www.r2solutions.org.)

E-Stewards

The e-Stewards Standard for Responsible Recycling and Reuse of Electronic Equipment® is an industry-specific environmental management system standard designed as the basis for the e-Stewards Certification. It was developed with input from experts in the recycling and asset-recovery industries, the environmental community, occupational health and safety professionals, and the certification and accreditation industries.

The e-Stewards Standard is written for international use and is consistent with international waste trade rules, social accountability standards, and environmental management system norms. Embedded within the e-

Stewards Standard is ISO 14001, which is the global standard for environmental management systems. Using the ISO 14001 standard as a framework, the e-Stewards Standard includes additional industry-specific performance requirements, resulting in a systemic, documented, and top-management commitment to best management practices for electronics recycling and reuse, 365 days a year. (Additional information can be found at www.e-stewards.org.)

WEEELABEX

WEEE stands for "waste electrical and electronic equipment." WEEELABEX is an acronym for the WEEE LABel of EXcellence project, which is run by the WEEE Forum in cooperation with stakeholders from the electronics manufacturers' community and WEEE processing industry. Manufacturers and recyclers associations are represented both in working groups and in the project's steering group, which is comprised of the European Committee of Domestic Equipment Manufacturers (CECED), European Lamp Companies Federation (ELC), DIGITALEUROPE, and the European Electronics Recyclers Association (EERA).

The WEEELABEX project (2009-2012) is co-financed by the European Community under the LIFE program (LIFE07 ENV/B/000041). It aims to design a set of European standards with respect to the collection, sorting, storage, transportation, preparation for reuse, treatment, processing, and disposal of all kinds of WEEE. In addition, it seeks to develop a harmonized set of rules and procedures that will provide for conformity verification. (Additional information on WEEELABEX can be found at www.weee-forum.org/weeelabexproject.)

XI. Suggestions for Future Work

This first edition of the EDE metric is meant to introduce the industry to the concepts and metric. The Green Grid task force believes that there are additional enhancements that can be made based on feedback from real-world use. Table 4 lists some concepts around which to begin those discussions.

Table 4. Concepts related to the EDE metric that could be pursued in future efforts

Potential Subjects for Industry Feedback & Validation
Introduction of a responsibility transparency score for classification of EDE results, similar to the categories used with the PUE metric (e.g., unrecognized, reported, registered, certified)
Global implementation of the EDE metric—how to use it in countries where certification does not yet exist
Weighting the EDE metric relative to the way an organization manages its decommissioned IT EEE. The desire to remain neutral on the disposal option means that it may be relatively easy to achieve high EDE results without

Potential Subjects for Industry Feedback & Validation
tackling some of the most pertinent issues. Some degree of weighting should be considered for the different management options based on the outcomes that they achieve. For example, reuse should be weighted higher than recycling (once life cycle energy use is likely to be lower) and the various recycling options should be given preference based on the extent to which they maximize material recovery and minimize hazardous emissions. If pursued, the weighting practices should be discussed and clearly established because the same incentives may not exist as they have for energy and utilization efficiency work undertaken by TGG.
Various levels and types of recycling effectiveness
Definition of "responsible," using industry feedback as it is obtained to define the minimum requirements for "responsible" • Parts and component reuse • Whole system reuse

Additionally, the TGG task force recommends the following items be developed to support adoption of the EDE metric.

- Best practices document that addresses:
  - — Gathering data for calculation, including where to find the data, how to organize it, etc.
  - — How an organization can use the EDE metric to improve the value of its disposed assets
  - — How to appropriately use EDE, such as guidelines as to when it can be used
- Document containing a metapolicy for recycling, which explains how an organization can create a responsible WEEE disposal policy and includes any guidance TGG can provide
- Refinement of EDE metric by role (e.g., corporate consumer versus recycler), by industry, etc. As the task force and the EDE user community become more sophisticated, TGG may find that:
  - — Different industries need a different metric or means of calculating EDE
  - — Organizational consumers of IT EEE and recyclers need a different metric or means of calculating EDE
- FAQs that answer anticipated questions about the EDE metric (developed to stand alone and/or be included in the best practices document)

While TGG metrics such as PUE, ERE, and now EDE address various key energy and sustainability elements in the data center, TGG also is driving the development of more advanced metrics such as data center productivity. To promote its metrics and encourage greater data center energy efficiency for businesses, academia, and governments around the world, TGG will continue to publish white papers, technical briefs,

books, and articles, along with hosting tech forums that provide detailed guidance on using the metrics and developing alliances with other organizations that promote a similar vision and goals.

XII. Conclusion

The collective goal of this white paper is to provide a metric that will assist in improving the responsible disposal of IT EEE around the world. This white paper will join a collection of evolving works on the topic of responsible WEEE disposal. The Green Grid's EDE metric is a standardized way to collect and report on the effective disposal of IT EEE. Over time, TGG's intent is to show improvement in responsible WEEE disposal from organizations and to raise industry awareness of its importance, which will create new and improved channels for reducing the negative impact of discarded IT EEE.

XIII. References

1. Emerson Network Power Recycling Ratios: The Next Step for Data Center Sustainability www.emersonnetworkpower.com/en-US/Documents/EDC/Market%20Position%20Paper%20-%20Recycling%20Ratios_6.pdf.

XIV. About The Green Grid

The Green Grid Association is a non-profit, open industry consortium of end users, policy makers, technology providers, facility architects, and utility companies that works to improve the resource efficiency of information technology and data centers throughout the world. With its member organizations around the world, The Green Grid seeks to unite global industry efforts, create a common set of metrics, and develop technical resources and educational tools to further its goals. Additional information is available at www.thegreengrid.org.

XV. Glossary

This glossary is comprised of draft definitions from the Partnership for Action on Computing Equipment (PACE) and should be considered a work in progress. The Green Grid intends to keep these definitions aligned with ongoing revisions to the PACE source document. (http://archive.basel.int/industry/compartnership/)

[**Note:** These terms were developed for the purpose of the report on Environmentally Sound Management (ESM) criteria recommendations, individual project guidelines, and overall Guidance Document developed under PACE. They should not be considered as being legally binding or agreed to internationally. Their purpose is to assist readers in better understanding the PACE documents.

Assemblies:	Multiple electronic components assembled in a device that is in itself used as a component.
Basel Convention:	United Nations Environment Programme's (UNEP's) March 22, 1989, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which came into force in 1992.
Cleaning:	Removing dirt, dust, and stains, and making cosmetic repairs.
Component:	Element with electrical or electronic functionality connected together with other components, usually by soldering to a printed circuit board, to create an electronic circuit with a particular function (e.g., amplifier, radio receiver, or oscillator).
Computing equipment:	Computing equipment includes personal computers (PCs) and associated displays, printers, and peripherals; personal desktop computers, including the central processing unit and all other parts contained in the computer; personal notebooks and laptop computers, including the docking station, central processing unit, and all other parts contained in the computer; computer monitors, including the following types of computer monitors: (a) cathode ray tube (b) liquid crystal display (c) plasma; computer keyboards, mice, and cables; computer printers (a) including (i) dot matrix; (ii) ink jet; (iii) laser; (iv) thermal, and (b) including any computer printers with scanning and/or facsimile capabilities.

Defective/Defect: Defective **computing equipment** is equipment that is delivered from the supply chain and last manufacturer in a condition that is not as it was designed to be sold, or the equipment breaks or malfunctions due to a condition that is not as it was designed. Defective equipment does not include equipment that loses functional or cosmetic value as a result of normal wear and usage or as a result of consumer negligence.

Direct reuse: Continued use of **computing equipment** and **components** by another person without the necessity of **repair, refurbishment**, or hardware **upgrade**, provided that such continued use is for the intended purpose of computing equipment and components.

Dismantling: Taking apart **computing equipment, components**, or **assemblies** in order to separate materials and/or increase options for **reuse, refurbishment,** or **recycling** and to maximize recovery value.

Disposal: Any operations specified in Annex IV of the Basel Convention (Article 2, paragraph 4 of the Basel Convention).

Donation: Any action to transfer **computing equipment**, or its **components** that are still **fully functional**, to another owner without any monetary rewards, benefits, or barter.

End-of-life computing equipment: Individual piece of **computing equipment** that is no longer suitable for use and is intended for **dismantling** and recovery of spare parts or is destined for **recycling** or final **disposal**. It also includes off-specification or new **computing equipment** that has been sent for **recycling** or final **disposal**.

End-of-use: **Computing equipment** that is no longer used as intended by the previous owner but may be **fully functional** and used appropriately by others.

Environmentally sound management (ESM): Taking all practicable steps to ensure that used and/or end-of-life products or wastes are managed in a manner that will protect human health and the environment.

Essential key function: The originally intended function(s) of a unit of equipment or **component** that will satisfactorily enable the equipment or component to be reused.

Evaluation: The initial process by which used **computing equipment** is assessed to determine whether it is likely to be suitable for **refurbishment/repair** or **recycling**.

Final disposal: Relevant operations specified in Annex IVA of the Basel Convention.

Fully functional/full functionality: **Computing equipment** or **components** are "fully functional" when they have been **tested** and demonstrated to be capable of performing the **essential key functions** they were designed to perform.

Hydrometallurgical processing: Uses of aqueous chemistry for the recovery of metals from ores, concentrates, or recyclable wastes or products. Typically, hydrometallurgy consists of three steps: (a) leaching using an acidic or basic aqueous solution to dissolve the desired metal at ambient or elevated pressures and temperatures; (b) solution concentration, purification, and metal recovery using methods such as: precipitation, cementation, solvent extraction, gaseous reduction, ion exchange, electrowinning or electrorefining, and (c) recycling of reagents and treatment of effluents. Hydrometallurgical operations in authorized industrial-scale facilities are distinct from unauthorized, illegal, environmentally harmful practices in the informal sector.

Incineration: A thermal treatment technology by which wastes, sludges, or residues are burned or destroyed at temperatures ranging from 850°C to more than 1100°C.

Labeling: The process by which individual pieces or batches of **computing equipment** are marked to designate their status according to the PACE guidelines.

Landfilling: The placement of waste in, or on top of, ground containments, which is then generally covered with soil. Engineered landfills are disposal sites that are selected and designed to minimize the chance of release of hazardous substances into the environment, e.g., using plastic landfill liners and **leachate** collection systems.

Leachate: Contaminated water or liquids resulting from the contact of rain, surface and ground waters, or other pollutants with waste.

Mechanical separation: Process of using machinery to separate **computing equipment** into various materials *or* **components**.

Potential for reuse (reusable): **Computing equipment** and its **components** that possess, or are likely to possess, the necessary quality to be directly **reused** or reused after they have been **refurbished** or **repaired**.

Pyrometallurgical processing: Thermal processing of metals and ores, including roasting, smelting, and remelting.

Recycling: Relevant operations specified in Annex IVB of the Basel Convention.

Redeployment: Any action of new deployment or use by the owner of previously used **computing equipment** or its **components**.

Refurbishable: **Computing equipment** that can be refurbished or reconditioned, returning it to a working condition performing the **essential functions** for which it was designed.

Refurbished computing equipment: **Computing equipment** that has undergone **refurbishment**, returning it to working condition such that it can fulfill its originally conceived use with or without **upgrades**, meet applicable technical performance standards and regulatory requirements, and support possible upgrades.

Refurbishment: Process of creating refurbished or reconditioned **computing equipment**, including such activities as **cleaning**, data sanitization, and software **upgrading**.

Remanufacture: Any action necessary to build as-new products using **components** taken from previously used **computing equipment** as well as new **components**, if applicable. The output product meets the original OEM functionality and reliability specifications. Remanufacturing a product may require the complete or partial disassembly of the unit, replacement or reprocessing of all components that do not meet specifications, and **testing** to determine if the new product is **fully functional**. Depending on the applied **components**, this process may significantly change the unit's composition, purpose, and design.

Remarketing: Any action, including marketing activities, necessary to sell previously used **computing equipment** or its **components** directly or indirectly to customers.

Repairing: Process of only fixing a specified hardware fault or series of faults in **computing equipment**.

Reuse: Process of reusing used **computing equipment** or a functional **component** from used **computing equipment** in the same or a similar function, possibly after **refurbishing, repairing**, or **upgrading** it.

RoHS: Directive of the European Parliament and the Council on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (http://ec.europa.eu/environment/waste/weee/index_en.htm).

Segregation: Sorting out **computing equipment** from other (electronic) wastes for possible **reuse** or for **treatment** in downstream processes that may include **recycling,** reclamation, **refurbishment**, **repair**, **reuse**, or **disposal**.

Separation: Removing certain **components**/constituents (e.g., batteries) or materials from **computing equipment** by manual or mechanical means.

Small and medium-sized enterprises (SMEs): According to the European Commission, small and medium–sized enterprises are those businesses that employ fewer than 250 persons and that have an annual turnover not exceeding EUR 50 million and/or an annual balance sheet total not exceeding EUR 43 million.

States concerned: Means parties that are States of export, import, or transit.

Testing: Process by which used **computing equipment** is assessed against established protocol to determine whether it is suitable for **reuse**.

Transport of dangerous goods recommendations: UN recommendations on the transport of dangerous goods, which deal with classification, placarding, labeling, record keeping, etc. to protect public safety during transportation.

Treatment: Any physical, chemical, or mechanical activity in a facility that processes **computing equipment**, including **dismantling**, removal of hazardous **components**, **material recovery**, **recycling**, or preparation for **disposal**.

Upgrading: Process by which used **computing equipment** is modified by the addition of the latest software or hardware in order to increase its performance and/or functionality.

Used computing equipment:	**Computing equipment** that is not intended for use any longer by its owner but that is capable of being reused by another owner, **recycled**, **refurbished**, or **upgraded** by another owner.
WEEE Directive:	Directive of the European Parliament and the Council on Waste Electrical and Electronic Equipment.
Wastes:	Substances or objects that are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law (Article 2, paragraph 1 of the Basel Convention).
Working condition:	See **fully functional**.