



**Environmental Engineering (EE);  
Circular Economy (CE) in Information  
and Communication Technology (ICT);  
Definition of approaches, concepts and metrics**

*Full Standard Preview*  
*(Standard ID: TR 103 476 V1.1.2 (2018-02))*  
*Full Standard Preview*  
*(Standard ID: TR 103 476 V1.1.2 (2018-02))*  
<https://standards.iteh.ai/catalog/standards/sist/29-5d95-4fd1-afab-c5f6e5812572/etsi-tr-103-476-v1-1-2-2018-02>

---

**Reference**RTR/EE-EEPS33

---

**Keywords**e-waste management

---

**ETSI**

650 Route des Lucioles  
F-06921 Sophia Antipolis Cedex - FRANCE

---

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C  
Association à but non lucratif enregistrée à la  
Sous-Préfecture de Grasse (06) N° 7803/88

---

**Important notice**

---

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommiteeSupportStaff.aspx>

---

**Copyright Notification**

---

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.

All rights reserved.

**DECT™**, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

**3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

**oneM2M** logo is protected for the benefit of its Members.

**GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

# Contents

Intellectual Property Rights .....	5
Foreword.....	5
Modal verbs terminology.....	5
Introduction .....	5
1 Scope .....	7
2 References .....	7
2.1 Normative references .....	7
2.2 Informative references.....	7
3 Definitions and abbreviations.....	14
3.1 Definitions.....	14
3.2 Abbreviations .....	15
4 Introduction of Circular Economy concepts.....	15
5 Circular Economy related legislation and standards .....	17
6 Circular Economy business models .....	18
7 Circular Economy aspects and parameters affecting the environmental impact in different life cycle stages.....	18
7.0 Introduction .....	18
7.1 Raw Material Acquisition stage .....	18
7.1.1 Recycled content.....	18
7.1.2 Use of Critical Raw Materials.....	19
7.1.3 Proportion of re-used parts .....	19
7.2 Use stage .....	19
7.2.1 Durability.....	19
7.2.2 Upgradability .....	20
7.2.3 Removability.....	20
7.2.4 Reparability.....	21
7.3 End-of-Life stage.....	21
7.3.0 Introduction.....	21
7.3.1 Reusability .....	21
7.3.2 Recyclability .....	22
7.3.3 Recoverability.....	22
7.3.4 Refurbishability .....	23
7.3.5 Remanufactureability.....	23
8 Assessment methods and parameters .....	23
9 Examples of actions taken by the ICT industry.....	24
10 Reporting.....	25
11 Insights and conclusions.....	25
12 Suggestions for future standardization activities.....	25
<b>Annex A: Observations regarding CE .....</b>	<b>26</b>
A.0 Introduction .....	26
A.1 Recycling & e-waste .....	26
A.2 Recycled content example for metals.....	26
A.3 Design process.....	27
<b>Annex B: Additional examples of aspects, parameters, indicators and metrics .....</b>	<b>28</b>

B.0	Introduction .....	28
B.1	Resource productivity.....	28
B.2	Electronics Disposal Efficiency .....	28
B.3	Material Reutilization.....	28
B.4	Material Circularity Indicator.....	28
B.5	RRR benefit rates .....	29
B.6	Value-based circularity indicator for recycled content.....	29
B.7	Reusability.....	29
B.8	Company sustainability assessment model using CE indicators.....	29
<b>Annex C:</b>	<b>Use of LCA in the context of CE.....</b>	<b>30</b>
<b>Annex D:</b>	<b>Equation examples.....</b>	<b>31</b>
D.1	Cost of refurbishment.....	31
D.2	Cost of remanufacturing.....	31
<b>Annex E:</b>	<b>Reuse example.....</b>	<b>32</b>
History .....		33

**ITeh STANDARD PREVIEW**  
 (standards.iteh.ai)  
 Full standard:  
<https://standards.iteh.ai/catalog/standards/sist/a20f3e29-5d95-4fd1-afab-c5f6e5812572/etsi-tr-103-476-v1.1.2-2018-02>

---

# Intellectual Property Rights

## Essential patents

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

## Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

---

# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Environmental Engineering (EE).

---

# Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

---

# Introduction

In order to facilitate a shift to a more sustainable economy, Circular Economy (CE) has been proposed as one of the main ways forward. In this context, CE combined with Information and Telecommunication Technologies (ICT) could enable decoupling of economic growth and environmental impact [i.1]. Due to the seemingly scattered understanding of the topic of CE, and its main aspect Resource Efficiency (RE), it will be necessary to summarize, and then standardize, the manner in which CE and RE is quantified.

In 2015, the European Commission issued Mandate 543 (M/543), Standardization Request with regard to ecodesign requirements on material efficiency aspects for energy-related products [i.2] requesting European standardization organizations to develop needed standards. ETSI TC-EE accepted this mandate for ICT infrastructure goods. The present document is intended to provide input for standardization related to the Mandate 543.

The present document aims to provide an overview of the most important existing aspects, parameters, indicators, metrics, results, and business models used for estimating the resource efficiency and CE characteristics of ICT infrastructure goods as input for further standardization.

The present document is intended to provide an aid for all users of CE and RE concepts within the ICT infrastructure sphere.

ITU-T SG5 (Q13/5) has made preliminary descriptions of RE for ICT goods [i.3], which have been considered in the development of the present document which focuses more broadly on CE aspects for ICT infrastructure goods. Furthermore, the Methodology for Ecodesign of Energy-related Products (MEErP) report [i.4], as used in the framework of the Ecodesign Directive (2009/125/EC) [i.75], has been used as background information for materials efficiency aspects.

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

Full standard:  
<https://standards.iteh.ai/catalog/standards/sist/a203ce29-5d95-4fd1-afab-c5f6e5812572/etsi-tr-103-476-v1.1.2-2018-02>

---

# 1 Scope

The present document investigates current approaches, concepts and metrics of CE and RE and their applicability for the ICT infrastructure goods. The present document:

- 1) introduces CE and RE,
- 2) describes CE as used in the ICT industry,
- 3) describes existing CE and RE metrics and examples of their use,
- 4) proposes next steps in CE and RE standardization.

The scope of the present document includes the following aspects: upgradability, reparability, removability, durability, reusability, recyclability, recoverability, refurbishability, manufacturability. The following additional parameters, indicators and metrics are included: recycled content, use of critical raw materials, proportion of re-used parts.

The present document is revision of ETSI TR 103 476 (V1.1.1) [i.73]. It has the same technical content, but it clearly clarifies its relation to M/543 [i.2]. The first version [i.73] was prepared jointly by ETSI TC EE and ITU-T Study Group 5. It is published respectively by ITU and ETSI as Supplement ITU-T L.Suppl.28 [i.72] and the present document, which are equivalent in technical content.

The present document provides a guide to CE aspects, parameters, metrics, indicators for ICT infrastructure goods.

---

## 2 References

### 2.1 Normative references

Normative references are not applicable in the present document.

### 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Ellen MacArthur Foundation (2016): "Intelligent Assets: Unlocking the circular economy potential".

NOTE: Available at [http://www3.weforum.org/docs/WEF\\_Intelligent\\_Assets\\_Unlocking\\_the\\_Circular\\_Economy.pdf](http://www3.weforum.org/docs/WEF_Intelligent_Assets_Unlocking_the_Circular_Economy.pdf).

[i.2] M/543 Commission Implementing Decision (2015) 9096 of 17.12.2015 on a standardization request to the European standardization organizations as regards ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council.

NOTE: Available at <http://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=564>.

[i.3] International Telecommunication Union. L.Sup5: "Life-cycle management of ICT goods".

NOTE: Available at <https://www.itu.int/rec/T-REC-L.Sup5-201412-I>.

- [i.4] Biointelligence Service: "Material-efficiency ecodesign report and module to the methodology for the ecodesign of energy-related products (MEErP)".
- NOTE: Available at <http://ec.europa.eu/DocsRoom/documents/105/attachments/1/translations/en/renditions/pdf>.
- [i.5] ISO 22628:2002: "Road vehicles - Recyclability and recoverability - Calculation method".
- [i.6] ISO 14021:1999: "Environmental labels and declarations -- Self-declared environmental claims (Type II environmental labelling)".
- [i.7] Huysman, S.; Debaveye, S.; Schaubroeck, T. et al.: "The recyclability benefit rate of closed-loop and open-loop systems: A case study on plastic recycling in Flanders", Resources, Conservation and Recycling 2015, 101, 53-60.
- [i.8] Mueller, S.R.; Wager, P.A.; Widmer, R.; Williams, I.D.: "A geological reconnaissance of electrical and electronic waste as a source for rare earth metals", Waste Management 2015, 45, 226-234.
- NOTE: Available at <http://www.sciencedirect.com/science/article/pii/S0956053X15002329>.
- [i.9] Huysman, S.; Sala, S.; Mancini, L.; Ardente, F.; Alvarenga, R.A.; De Meester, S.; Dewulf, J.: "Toward a systematized framework for resource efficiency indicators", Resources, Conservation and Recycling 2015, 95, 68-76.
- NOTE: Available at <http://www.sciencedirect.com/science/article/pii/S0921344914002328>.
- [i.10] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: "Closing the loop - An EU action plan for the Circular Economy", COM(2015) 614 final, 2.12.2015.
- NOTE: Available at <https://ec.europa.eu/transparency/regdoc/rep/1/2015/EN/1-2015-614-EN-F1-1.PDF>.
- [i.11] Smalen, L.; Galkin, T.; Volkov, T.; Karyinen, H.; Tonteri, H.; Vatanen, S: "Life cycle methodology to assess resource efficiency of Nokia Flexi Mounting Kit".
- NOTE: [https://mycourses.aalto.fi/pluginfile.php/563974/mod\\_resource/content/1/Sustainability-in-electronics\\_20171012handout.pdf](https://mycourses.aalto.fi/pluginfile.php/563974/mod_resource/content/1/Sustainability-in-electronics_20171012handout.pdf)
- [i.12] Sihvonen, S., Ritola, T.: "Conceptualizing ReX for Aggregating End-of-life Strategies in Product Development", Procedia CIRP 2015, 29, 639-644.
- NOTE: Available at [http://ac.els-cdn.com/S2212827115000293/1-s2.0-S2212827115000293-main.pdf?\\_tid=6d9b9010-321e-11e6-a718-00000aab0f27&acdnat=1465901875\\_98cdb610cf6ae3ca776d0525bac8f390](http://ac.els-cdn.com/S2212827115000293/1-s2.0-S2212827115000293-main.pdf?_tid=6d9b9010-321e-11e6-a718-00000aab0f27&acdnat=1465901875_98cdb610cf6ae3ca776d0525bac8f390).
- [i.13] Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE).
- NOTE: Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012L0019>.
- [i.14] Larsen, A.H.; Bauer, B.; Musaeus, P.; Gylling, A.C.; Zacho, K.O.; Remmen, A.: "Forberedelse med henblik på genbrug af elektronikaffald", Miljøprojekt nr. 1739. 2015.
- NOTE: Available at [http://vbn.aau.dk/ws/files/223220188/Forberedelse\\_til\\_genbrug\\_af\\_elektronik\\_affald.pdf](http://vbn.aau.dk/ws/files/223220188/Forberedelse_til_genbrug_af_elektronik_affald.pdf).
- [i.15] BS PAS 141:2011: "Reuse of used and waste electrical and electronic equipment (UEEE and WEEE). Process management. Specification".
- NOTE: Available at <http://shop.bsigroup.com/en/ProductDetail/?pid=00000000030245346>.
- [i.16] Roos, G.: "Business model innovation to create and capture resource value in future circular material chains", Resources 2014, 3, 248-274.
- NOTE: Available at <http://www.mdpi.com/2079-9276/3/1/248>.



- [i.17] Accenture executive summary: "Waste to Wealth", 2015.
- NOTE: Available at [https://www.accenture.com/t20150916T215126\\_w/us-en/acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Strategy\\_7/Accenture-Waste-Wealth-Exec-Sum-FINAL.pdf](https://www.accenture.com/t20150916T215126_w/us-en/acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Strategy_7/Accenture-Waste-Wealth-Exec-Sum-FINAL.pdf).
- [i.18] Sultan, N.: "Servitization of the IT industry: the cloud", Strategic Change 2014, 23, 375-388.
- NOTE: Available at [https://www.researchgate.net/publication/264900709\\_Servitization\\_of\\_the\\_IT\\_Industry\\_The\\_Cloud\\_Phenomenon](https://www.researchgate.net/publication/264900709_Servitization_of_the_IT_Industry_The_Cloud_Phenomenon).
- [i.19] Lasanen, M.; Aubree, M.; Cassan, C.; Conte, A.; David, J.; Elayoubi, S.-E.; Galkin, T.; Grigore, V.; Le Masson, S.; Lees, J.; Louahlia-Gualous, H.; Marquet, D.; Mokhti, Z.; Nuaymi, L.; Scheck, H.-O.; Smalen, L.: "Environmental Friendly Mobile Radio Networks: Approaches of the European OPERA-Net 2 Project".
- NOTE: Available at [http://projects.celticplus.eu/opera-net2/docs/ICT2013\\_presentation\\_OPERA\\_Net2\\_May8th2013.pdf](http://projects.celticplus.eu/opera-net2/docs/ICT2013_presentation_OPERA_Net2_May8th2013.pdf).
- [i.20] Dechenaux, E.; Smalén, L.; Junno, T. et al.: "Materials efficiency: use of LCA to analyze the impacts of the evolution of a the evolution of a radio access radio access mounting kit", ETSI 3<sup>rd</sup> Workshop on ICT Energy Efficiency and Environmental Sustainability. 3 June 2015, Sophia Antipolis, France.
- NOTE: Available at [http://docbox.etsi.org/Workshop/2015/201506\\_EEWORKSHOP/SESSION03\\_LCA/LCA\\_Use\\_AnalyseImpacts\\_RadioAccess\\_MountingKit\\_Dechenaux\\_Orange.pdf](http://docbox.etsi.org/Workshop/2015/201506_EEWORKSHOP/SESSION03_LCA/LCA_Use_AnalyseImpacts_RadioAccess_MountingKit_Dechenaux_Orange.pdf).
- [i.21] ETSI ES 203 199: "Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services".
- [i.22] Recommendation ITU-T L.1410: "Methodology for environmental life cycle assessments of information and communication technology goods, networks and services".
- NOTE: Available at <http://www.itu.int/rec/T-REC-L.1410-201412-I>.
- [i.23] Ardente, F.; Mathieux, F.: "Identification and assessment of product's measures to improve resource efficiency: the case-study of an Energy using Product", Journal Cleaner Production 2014, 83, 126-141.
- NOTE: Available at <http://www.sciencedirect.com/science/article/pii/S0959652614007860>.
- [i.24] BS EN 15343:2007: "Plastics. Recycled plastics. Plastics recycling traceability and assessment of conformity and recycled content".
- NOTE: Available at <http://shop.bsigroup.com/ProductDetail/?pid=000000000030097507>.
- [i.25] Philips: "Closing the materials loop".
- NOTE: Available at <http://www.philips.com/b-dam/corporate/about-philips/sustainability/downloads/ecovision-methodologies/Closing-the-materials-loop-2016.pdf>.
- [i.26] Graedel, T.E.; Allwood, J.; Birat, J.P. Et al.: "Recycling rates of metals: a status report", 2011.
- NOTE: Available at [http://www.resourcepanel.org/file/381/download?token=he\\_rldvr](http://www.resourcepanel.org/file/381/download?token=he_rldvr)
- [i.27] Tata Steel Europe: "Sustainable Steel", 2007.
- NOTE: Available at [http://www.tsbsnordic.lv/file\\_source/StaticFiles/SustainableSteel%20KeyMessages.pdf](http://www.tsbsnordic.lv/file_source/StaticFiles/SustainableSteel%20KeyMessages.pdf).
- [i.28] European Commission: "Critical Raw Materials".
- NOTE: Available at [https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical\\_en](https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en).

- [i.29] Rogers, J.; Cooper, S.; Cooper, S.; Densley Tingley, D.; Braithwaite, N.; Moreno, M.; Salvia, G.: "Product Longevity and Shared Ownership: Sustainable Routes to Satisfying the World's Growing Demand for Goods", AIMS Energy 2015, 3, 547-561.
- NOTE: Available at <http://www.aimspress.com/article/10.3934/energy.2015.4.547>.
- [i.30] Stutz, M.; O'Connell, S.; Pflueger, J.: "Carbon Footprint of a Dell Rack Server", In Proceedings of Electronics Goes Green 2012+, Berlin, Germany, 9-12 September 2012.
- NOTE: Available at <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6360427>.
- [i.31] Nokia 2016: "Nokia Technology Vision 2020" white paper.
- NOTE: Available at <https://networks.nokia.com/innovation/technology-vision>.
- [i.32] Chan, C.A.; Gygax, A.F.; Leckie, C.; Wong, E.; Nirmalathas, A.; Hinton, K.: "Telecommunications energy and greenhouse gas emissions management for future network growth", Applied Energy 2016, 166, 174-185.
- NOTE: Available at [https://www.researchgate.net/publication/292970317\\_Telecommunications\\_energy\\_and\\_greenhouse\\_gas\\_emissions\\_management\\_for\\_future\\_network\\_growth](https://www.researchgate.net/publication/292970317_Telecommunications_energy_and_greenhouse_gas_emissions_management_for_future_network_growth).
- [i.33] Cheung, W.M.; Marsh, R.; Griffin, P.W. et al.: "Towards cleaner production: a roadmap for predicting product end-of-life costs at early design concept", Journal of Cleaner Production 2015, 87, 431-441.
- NOTE: Available at <http://www.sciencedirect.com/science/article/pii/S0959652614010750>.
- [i.34] Wang, C., Mitrouchev, P., Li, G., Lu, L.: "3D geometric removability analysis for virtual disassembly evaluation", In Proceedings 2014 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), Besancon, France, July 8-11, 2013 (pp. 1212-17).
- NOTE: Available at <http://ieeexplore.ieee.org/document/6878247?tp=&arnumber=6878247&contentType=Conference%20Publications>.
- [i.35] Tian, G., Qiang, T., Chu, J., Xu, G., Zhou, W.: "Efficiency Optimization for Disassembly Tools via Using NN-GA Approach". Math Probl Eng 2013, Article ID 173736.
- NOTE: Available at <http://www.hindawi.com/journals/mpe/2013/173736/>.
- [i.36] IEC TR 62635:2012: "Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment".
- NOTE: Available at <https://webstore.iec.ch/publication/7292>.
- [i.37] Reuter, M. A.; Van Schaik, A.: "10 Design for recycling rules, product centric recycling & urban/landfill mining", In Proceedings 2<sup>nd</sup> International Academic Symposium on Enhance Landfill Mining, Houthalen-Helchteren, Belgium, October 14-16, 2013 (pp. 103-117).
- NOTE: Available at [https://www.researchgate.net/publication/270340747\\_10\\_DESIGN\\_FOR\\_RECYCLING\\_RULES\\_PRODUCT\\_CENTRIC\\_RECYCLING\\_URBANLANDFILL\\_MINING](https://www.researchgate.net/publication/270340747_10_DESIGN_FOR_RECYCLING_RULES_PRODUCT_CENTRIC_RECYCLING_URBANLANDFILL_MINING)
- [i.38] Mangold, J. A.: "Evaluating the end-of-life phase of consumer electronics: methods and tools to improve product design and material recovery". PhD thesis, University of California, Berkeley, 2013. ProQuest.
- NOTE: Available at <http://escholarship.org/uc/item/9tj3t93z>.
- [i.39] Balkenende, A.; Bakker, C.: "Developments and challenges in design for sustainability of electronics". In Transdisciplinary lifecycle analysis of systems: Proceedings of the 22<sup>nd</sup> ISPE Inc. International Conference on Concurrent Engineering, July 20-23, 2015 (Vol. 2, p. 3). IOS Press.
- NOTE: Available at <http://ebooks.iospress.nl/volumearticle/39947>.

- [i.40] International Telecommunication Union: "Connect 2020 Agenda".
- NOTE: Available at <http://www.itu.int/en/connect2020/Pages/default.aspx>.
- [i.41] Liebmann, A.: "ICT waste handling: regional and global end-of-life treatment scenarios for ICT equipment", KTH:s Publikationsdatabas DiVA. 2015.
- NOTE: Available at <http://www.diva-portal.org/smash/record.jsf?pid=diva2:839633>.
- [i.42] Dretsch, G. 2015: "End-of-Life of ICT Equipment".
- NOTE: Available at [https://docbox.etsi.org/Workshop/2015/201506\\_EEWORKSHOP/SESSION04\\_Environm\\_Sustain\\_Aspets/Managmt\\_EndOfLife\\_ICT\\_equipment\\_WEEE\\_Dretsch\\_Orange.pdf](https://docbox.etsi.org/Workshop/2015/201506_EEWORKSHOP/SESSION04_Environm_Sustain_Aspets/Managmt_EndOfLife_ICT_equipment_WEEE_Dretsch_Orange.pdf).
- [i.43] O'Connell, S.; Shrivastava, P.; Moriarty, T.; Schafer, S.: "Going Green, CARE INNOVATION 2014", November 17 - 20, 2014, Schoenbrunn Palace Conference Centre, Vienna (Austria).
- NOTE: Available at <http://www.4980.timewarp.at/CARE/CI2014/PDFs/Abstract%20Book%20final.pdf>.
- [i.44] Bakas, I., Herczeg, M., Vea, E. B., Frâne, A., Youhanan, L., & Baxter, J. (2016): "Critical metals in discarded electronics: Mapping recycling potentials from selected waste electronics in the Nordic region".
- [i.45] World Steel Association: "World steel figures in 2012".
- NOTE: Available at [http://www.steelonthenet.com/kb/files/World\\_Steel\\_in\\_Figures\\_2012.pdf](http://www.steelonthenet.com/kb/files/World_Steel_in_Figures_2012.pdf).
- [i.46] World Steel Association: "Steel Statistical Yearbook 2014".
- NOTE: Available at [http://www.steelonthenet.com/kb/files/Steel\\_Statistical\\_Yearbook\\_2014.pdf](http://www.steelonthenet.com/kb/files/Steel_Statistical_Yearbook_2014.pdf).
- [i.47] IEC 62430:2009: "Environmentally conscious design for electrical and electronic products".
- NOTE: Available at <https://webstore.iec.ch/publication/7005>.
- [i.48] Andrae, A.S.G.; Xia, M.; Zhang, J.; Tang, X.: "Practical Eco-Design and Eco-Innovation of Consumer Electronics - The Case of Mobile Phones", Challenges 2016, 7, 3.
- NOTE: Available at <http://www.mdpi.com/2078-1547/7/1/3>.
- [i.49] Ritthoff, M.; Rohn, H.; Liedtke, C.: "Calculating MIPS: Resource productivity of products and services" (No. 27e), Wuppertal Spezial, Wuppertal Institut für Klima, Umwelt und Energie. 2002.
- NOTE: Available at <http://www.econstor.eu/bitstream/10419/59294/1/485276682.pdf>.
- [i.50] McKinsey article: "Are you ready for the resource revolution?" March 2014.
- NOTE: Available at [http://www.mckinsey.com/insights/sustainability/are\\_you\\_ready\\_for\\_the\\_resource\\_revolution](http://www.mckinsey.com/insights/sustainability/are_you_ready_for_the_resource_revolution).
- [i.51] European Commission Staff Working Document: "Analysis of an EU target for resource productivity", 2014.
- NOTE: Available at <http://ec.europa.eu/environment/circular-economy/pdf/AnalysisEUtarget.pdf>.
- [i.52] The Green Grid®: "Electronic Disposal Efficiency (EDE): An IT Recycling Metric for Enterprises and Data Centers", 2012.
- NOTE: Available at <http://www.datacenterdynamics.com/content-tracks/servers-storage/the-green-grid-brings-in-new-metric-for-equipment-use/74439.article>.
- [i.53] McDonough, W.; Braungart, M.: "Cradle to cradle: Remaking the way we make things", 1<sup>st</sup> ed.; McDonough, W. Braungart, M., Eds.; North Point Press: New York, NY, USA, 2002; pp. 3-193.
- NOTE: Available at <http://www.mcdonough.com/speaking-writing/cradle-to-cradle/>.